MOBILIZING *the* PAST *for a* DIGITAL FUTURE

The Potential of Digital Archaeology

Edited by
Erin Walcek Averett
Jody Michael Gordon
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Preface & Acknowledgments

This volume stems from the workshop, "Mobilizing the Past for a Digital Future: the Future of Digital Archaeology," funded by a National Endowment for the Humanities Digital Humanities Start-Up grant (#HD-51851-14), which took place 27-28 February 2015 at Wentworth Institute of Technology in Boston (http://uwm.edu/mobilizing-the-past/). The workshop, organized by this volume's editors, was largely spurred by our own attempts with developing a digital archaeological workflow using mobile tablet computers on the Athienou Archaeological Project (http://aap.toumazou.org; Gordon *et al.*, Ch. 1.4) and our concern for what the future of a mobile and digital archaeology might be. Our initial experiments were exciting, challenging, and rewarding; yet, we were also frustrated by the lack of intra-disciplinary discourse between projects utilizing digital approaches to facilitate archaeological data recording and processing.

Based on our experiences, we decided to initiate a dialogue that could inform our own work and be of use to other projects struggling with similar challenges. Hence, the "Mobilizing the Past" workshop concept was born and a range of digital archaeologists, working in private and academic settings in both Old World and New World archaeology, were invited to participate. In addition, a livestream of the workshop allowed the active participation on Twitter from over 21 countires, including 31 US states (@MobileArc15, #MobileArc).[1]

[1] For commentary produced by the social media followers for this event, see: https://twitter.com/electricarchaeo/status/571866193667047424, http://shawngraham.github.io/exercise/mobilearcday1wordcloud.html, https://twitter.com/electricarchaeo/status/571867092091338752, http://www.diachronicdesign.com/blog/2015/02/28/15-mobilizing-the-past-for-the-digital-future-conference-day-1-roundup/.

Although the workshop was initially aimed at processes of archaeological data recording in the field, it soon became clear that these practices were entangled with larger digital archaeological systems and even socio-economic and ethical concerns. Thus, the final workshop's discursive purview expanded beyond the use of mobile devices in the field to embrace a range of issues currently affecting digital archaeology, which we define as the use of computerized, and especially internet-compatible and portable, tools and systems aimed at facilitating the documentation and interpretation of material culture as well as its publication and dissemination. In total, the workshop included 21 presentations organized into five sessions (see program, http://mobilizingthepast.mukurtu.net/digital-heritage/mobilizing-past-conference-program), including a keynote lecture by John Wallrodt on the state of the field, "Why paperless?: Digital Technology and Archaeology," and a plenary lecture by Bernard Frischer, "The Ara Pacis and Montecitorio Obelisk of Augustus: A Simpirical Investigation," which explored how digital data can be transformed into virtual archaeological landscapes.

The session themes were specifically devised to explore how archaeological data was digitally collected, processed, and analyzed as it moved from the trench to the lab to the digital repository. The first session, "App/Database Development and Use for Mobile Computing in Archaeology," included papers primarily focused on software for field recording and spatial visualization. The second session, "Mobile Computing in the Field," assembled a range of presenters whose projects had actively utilized mobile computing devices (such as Apple iPads) for archaeological data recording and was concerned with shedding light on their utility within a range of fieldwork situations. The third session, "Systems for Archaeological Data Management," offered presentations on several types of archaeological workflows that marshal born-digital data from the field to publication, including fully bespoken paperless systems, do-it-yourself ("DIY") paperless systems, and hybrid digital-paper systems. The fourth and final session, "Pedagogy, Data Curation, and Reflection," mainly dealt with teaching digital methodologies and the use of digital repositories and linked open data to enhance field research. This session's final paper, William Caraher's "Toward a Slow Archaeology," however, noted digital archaeology's successes in terms of time and money saved and the collection of more data, but also called for a more measured consideration of the significant changes that these technologies are having on how archaeologists engage with and interpret archaeological materials.

The workshop's overarching goal was to bring together leading practitioners of digital archaeology in order to discuss the use, creation, and implementation of mobile and digital, or so-called "paperless," archaeological data recording systems. Originally, we hoped to come up with a range of best practices for mobile computing in the field – a manual of sorts – that could be used by newer projects interested in experimenting with digital methods, or even by established projects hoping to revise their digital workflows in order to increase their efficiency or, alternatively, reflect on their utility and ethical implications. Yet, what the workshop ultimately proved is that there are many ways to "do" digital archaeology, and that archaeology as a discipline is engaged in a process of discovering what digital archaeology should (and, perhaps, should not) be as we progress towards a future where all archaeologists, whether they like it or not, must engage with what Steven Ellis has called the "digital filter."

So, (un)fortunately, this volume is not a "how-to" manual. In the end, there seems to be no uniform way to "mobilize the past." Instead, this volume reprises the workshop's presentations—now revised and enriched based on the meeting's debates as well as the editorial and peer review processes—in order to provide archaeologists with an extremely rich, diverse, and reflexive overview of the process of defining what digital archaeology is and what it can and should perhaps be. It also provides two erudite response papers that together form a didactic manifesto aimed at outlining a possible future for digital archaeology that is critical, diverse, data-rich, efficient, open, and most importantly, ethical. If this volume, which we offer both expeditiously and freely, helps make this ethos a reality, we foresee a bright future for mobilizing the past.

* * *

No multifaceted academic endeavor like *Mobilizing the Past* can be realized without the support of a range of institutions and individuals who believe in the organizers' plans and goals. Thus, we would like to thank the following institutions and individuals for their logistical, financial, and academic support in making both the workshop and this volume a reality. First and foremost, we extend our gratitude toward The National Endowment for the Humanities (NEH) for providing us with a Digital Humanities Start-Up Grant (#HD-51851-14), and especially to Jennifer Serventi and Perry Collins for their invaluable assistance through the application process and beyond. Without the financial support from this grant the workshop and this publication would not have been possible. We would also like to thank Susan Alcock (Special Counsel for Institutional Outreach and Engagement, University of Michigan) for supporting our grant application and workshop.

The workshop was graciously hosted by Wentworth Institute of Technology (Boston, MA). For help with hosting we would like to thank in particular Zorica Pantić (President), Russell Pinizzotto (Provost), Charlene Roy (Director of Business Services), Patrick Hafford (Dean, College of Arts and Sciences), Ronald Bernier (Chair, Humanities and Social Sciences), Charles Wiseman (Chair, Computer Science and Networking), Tristan Cary (Manager of User Services, Media Services), and Claudio Santiago (Utility Coordinator, Physical Plant).

Invaluable financial and logistical support was also generously provided by the Department of Fine and Performing Arts and Sponsored Programs Administration at Creighton University (Omaha, NE). In particular, we are grateful to Fred Hanna (Chair, Fine and Performing Arts) and J. Buresh (Program Manager, Fine and Performing Arts), and to Beth Herr (Director, Sponsored Programs Administration) and Barbara Bittner (Senior Communications Management, Sponsored Programs Administration) for assistance managing the NEH grant and more. Additional support was provided by The University of Wisconsin-Milwaukee; in particular, David Clark (Associate Dean, College of Letters and Science), and Kate Negri (Academic Department Assistant, Department of Art History). Further support was provided by Davidson College and, most importantly, we express our gratitude to Michael K. Toumazou (Director, Athienou Archaeological Project) for believing in and supporting our research and for allowing us to integrate mobile devices and digital workflows in the field.

The workshop itself benefitted from the help of Kathryn Grossman (Massachusetts Institute of Technology) and Tate Paulette (Brown University) for on-site registration and much more. Special thanks goes to Daniel Coslett (University of Washington) for graphic design work for both the workshop materials and this volume. We would also like to thank Scott Moore (Indiana University of Pennsylvania) for managing our workshop social media presence and his support throughout this project from workshop to publication.

This publication was a pleasure to edit, thanks in no small part to Bill Caraher (Director and Publisher, The Digital Press at the University of North Dakota), who provided us with an outstanding collaborative publishing experience. We would also like to thank Jennifer Sacher (Managing Editor, INSTAP Academic Press) for her conscientious copyediting and Brandon Olson for his careful reading of the final proofs. Moreover, we sincerely appreciate the efforts of this volume's anonymous reviewers, who provided detailed, thought-provoking, and timely feedback on the papers; their insights greatly improved this publication. We are also grateful to Michael Ashley and his team at the Center for Digital Archaeology for their help setting up the accompanying Mobilizing the Past Mukurtu site and Kristin M. Woodward of the University of Wisconsin-Milwaukee Libraries for assistance with publishing and archiving this project through UWM Digital Commons. In addition, we are grateful to the volume's two respondents, Morag Kersel (DePaul University) and Adam Rabinowitz (University of Texas at Austin), who generated erudite responses to the chapters in the volume. Last but not least, we owe our gratitude to all of the presenters who attended the workshop in Boston, our audience from the Boston area, and our colleagues on Twitter (and most notably, Shawn Graham of Carlton University for his word clouds) who keenly "tuned in" via the workshop's livestream. Finally, we extend our warmest thanks to the contributors of this volume for their excellent and timely chapters. This volume, of course, would not have been possible without such excellent papers.

As this list of collaborators demonstrates, the discipline of archaeology and its digital future remains a vital area of interest for people who value the past's ability to inform the present, and who recognize our ethical responsibility to consider technology's role in contemporary society. For our part, we hope that the experiences and issues presented in this volume help to shape new intra-disciplinary and critical ways of mobilizing the past so that human knowledge can continue to develop ethically at the intersection of archaeology and technology.

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October 1, 2016

How To Use This Book

The Digital Press at the University of North Dakota is a collaborative press and *Mobilizing the Past for a Digital Future* is an open, collaborative project. The synergistic nature of this project manifests itself in the two links that appear in a box at the end of every chapter.

The first link directs the reader to a site dedicated to the book, which is powered and hosted by the Center for Digital Archaeology's (CoDA) Mukurtu.net. The Murkutu application was designed to help indigenous communities share and manage their cultural heritage, but we have adapted it to share the digital heritage produced at the "Mobilizing the Past" workshop and during the course of making this book. Michael Ashley, the Director of Technology at CoDA, participated in the "Mobilizing the Past" workshop and facilitated our collaboration. The Mukurtu.net site (https://mobilizingthepast.mukurtu.net) has space dedicated to every chapter that includes a PDF of the chapter, a video of the paper presented at the workshop, and any supplemental material supplied by the authors. The QR code in the box directs readers to the same space and is designed to streamline the digital integration of the paper book.

The second link in the box provides open access to the individual chapter archived within University of Wisconsin-Milwaukee's installation of Digital Commons, where the entire volume can also be downloaded. Kristin M. Woodward (UWM Libraries) facilitated the creation of these pages and ensured that the book and individual chapters included proper metadata.

Our hope is that these collaborations, in addition to the open license under which this book is published, expose the book to a wider audience and provide a platform that ensures the continued availability of the digital complements and supplements to the text. Partnerships with CoDA and the University of Wisconsin-Milwaukee reflect the collaborative spirit of The Digital Press, this project, and digital archaeology in general.

Abbreviations

AAI	Alexandria Archive Institute
AAP	Athienou Archaeological Project
ABS	acrylonitrile butadiene styrene (plastic)
ADS	Archaeological Data Service
Alt-Acs	Alternative Academics
API	application programming interface
ARA	archaeological resource assessment
ARC	Australian Research Council
ARIS	adaptive resolution imaging sonar
ASV	autonomous surface vehicle
BLM	Bureau of Land Management
BLOB	Binary Large Object
BOR	Bureau of Reclamation
BYOD	bring your own device
CAD	computer-aided design
CDL	California Digital Library
CHDK	Canon Hack Development Kit
cm	centimeter/s
CMOS	complementary metal-oxide semiconductor
CoDA	Center for Digital Archaeology
COLLADA	COLLAborative Design Activity
CRM	cultural resource management
CSS	Cascading Style Sheet
CSV	comma separated values
DBMS	desktop database management system
DEM	digital elevation model
DINAA	Digital Index of North American Archaeology
DIY	do-it-yourself
DoD	Department of Defense
DVL	doppler velocity log
EAV	entity-attribute-value
EDM	electronic distance measurement
EU	excavation unit/s
FAIMS	Federated Archaeological Information Management System
fMRI	functional magnetic resonance imaging
GIS	geographical information system
GCP	ground control point
GNSS	global navigation satellite system
GPR	ground-penetrating radar

GUI	graphic user interface
ha	hectare/s
hr	hour/s
Hz	Hertz
HDSM	high-density survey and measurement
ICE	Image Composite Editor (Microsoft)
iOS	iPhone operating system
INS	inertial motion sensor
IPinCH	Intellectual Property in Cultural Heritage
IT	information technology
KAP	Kaymakçı Archaeological Project
KARS	Keos Archaeological Regional Survey
km	kilometer/s
LABUST	Laboratory for Underwater Systems and Technologies (University of Zagreb)
LAN	local area network
LIEF	Linkage Infrastructure Equipment and Facilities
LOD	linked open data
LTE	Long-Term Evolution
m	meter/s
masl	meters above sea level
MEMSAP	Malawi Earlier-Middle Stone Age Project
MOA	memoranda of agreement
MOOC	Massive Online Open Course
NGWSP	Navajo-Gallup Water Supply Project
NeCTAR	National eResearch Collaboration Tools and Resources
NEH	National Endowment for the Humanities
NHPA	National Historic Preservation Act
NPS	National Park Service
NRHP	National Register of Historic Places
NSF	National Science Foundation
OCR	optical character reader
OS	operating system
PA	programmatic agreement
PAP	pole aerial photography
PARP:PS	Pompeii Archaeological Research Project: Porta Stabia
PATA	Proyecto Arqueológico Tuti Antiguo
PBMP	Pompeii Bibliography and Mapping Project
PDA	personal digital assistant

PIARA	Proyecto de Investigación Arqueológico Regional Ancash
PKAP	Pyla-Koutsopetra Archaeological Project
Pladypos	PLAtform for DYnamic POSitioning
PLoS	Public Library of Science
PQP	Pompeii Quadriporticus Project
PZAC	Proyecto Arqueológico Zaña Colonial
QA	quality assurance
QC	quality control
QR	quick response
REVEAL	Reconstruction and Exploratory Visualization: Engineering meets ArchaeoLogy
ROS	robot operating system
ROV	remotely operated vehicle
RRN	Reciprocal Research Network
RSS	Rich Site Summary
RTK	real-time kinetic global navigation satellite system
SfM	structure from motion
SHPO	State Historic Preservation Office
SKAP	Say Kah Archaeological Project
SLAM	simultaneous localization and mapping
SMU	square meter unit/s
SU	stratigraphic unit/s
SVP	Sangro Valley Project
TCP	traditional cultural properties
tDAR	the Digital Archaeological Record
UAV	unmanned aerial vehicle
UNASAM	National University of Ancash, Santiago Antúnez de Mayolo
UQ	University of Queensland
USACE	U.S. Army Corp of Engineers
USBL	ultra-short baseline
USFS	U.S. Forest Service
USV	unmanned surface vehicle
UTM	universal transverse mercator
XML	Extensible Markup Language

1.3.
Sangro Valley and the Five (Paperless) Seasons: Lessons on Building Effective Digital Recording Workflows for Archaeological Fieldwork

Christopher F. Motz

On March 8, 2011, I sent a foolish email. Earlier, during the winter, I had played around with creating a basic FileMaker Pro database for my iPhone that could be used in the field. I thought it had potential for field use, and I had read about iPads being used at Pompeii by the Pompeii Archaeological Research Project: Porta Stabia (PARP:PS) team the previous summer (Apple Inc. 2010; Ellis and Wallrodt 2011), so I sent a few screenshots to my excavation director and asked if she would be interested in using such a system during the coming excavation season of the Sangro Valley Project (SVP). At most I thought she might agree to test its use with one or two iPads, and maybe switch over fully the following year. Instead, after a brief email exchange she told me she wanted the project to go entirely paperless in the coming summer.

My first reaction was surprise. My second was fear. What had I gotten myself into? I had four months to develop a full excavation database, complete with syncing and new image handling procedures. I had limited experience with FileMaker, was a full-time, first-year graduate student, and had a part-time job. Compounding all of this was a lack of resources that could help one build this kind of system. Excavation databases were not new, but this particular combination of hardware and software had never before been available. Furthermore, a research database and a recording system are two different beasts. Even proper iOS app developers were still figuring out how to design effective interfaces for tablets. Our experiment easily could have failed.

Through a combination of long hours, help and advice from John Wallrodt (including his blog posts on http://paperlessrchaeology.com, which have been a valuable resource for many other projects and remain the best starting point for those interested in building a paperless recording system; see Butina 2014; see also Bria and DeTore, Ch. 1.5; Gordon *et al.*, Ch. 1.4) and Google, I managed to build a functional but unfinished system. It worked, but it was a beta-quality solution that required constant maintenance and bug fixes. All of the critical parts worked at the beginning of the season, but I continued to add and change many elements throughout the summer. Our field staff's patience and their willingness to cooperate in this experiment played a large part in its success.

Since 2011 I have continued working on the system for the Sangro Valley Project (directed by Susan Kane; see http://www.sangro.org). I have also developed a paperless recording system for the Say Kah Archaeological Project in Belize (SKAP, directed by Sarah Jackson and Linda Brown), which was deployed for the first time in the summer of 2015, and since 2013 I have managed and continued the development of the paperless system that John Wallrodt built (Ellis and Wallrodt 2011; Wallrodt *et al.* 2015; Wallrodt, Ch. 1.1) for PARP:PS (directed by Steven Ellis; Ellis *et al.* 2015; for a full bibliography, see http://classics.uc.edu/pompeii/; see also Ellis, Ch. 1.2). During this time, my skills as a FileMaker developer have grown considerably, but far more valuable are the lessons I have learned from our successes and failures, from watching people use paperless systems, and from the feedback they have provided.

In the first part of this chapter I will summarize the paperless system at SVP and how it has evolved from the initial creation and deployment in 2011, to the redesigned interface in 2012, and to a focus on documentation in 2013. I will then present some lessons learned during five seasons of paperless recording at SVP (2011–2015), supplemented by observations I made during my work with SKAP (2015) and PARP:PS (2013–2015). I will identify some of the most common problems that I have encountered during the design and use of paperless recording systems, and I will offer some recommendations for avoiding or fixing them. Many of these problems are not unique to projects with digital recording systems, and most of the difficulties were not technical in nature. Rather, many of the most significant problems arose from integrating workflows: not only digital and physical workflows, but also the workflows of different actors in the project. Finally, I will engage with recent critiques of paperless field recording, in particular Bill Caraher's provocative philosophy of "Slow Archaeology," which cautions against the (over)eager pursuit of efficiency and promotes methods that nurture interpretative insight (Caraher 2013; 2015b; Ch. 4.1). I will offer SKAP as a case study of how digital recording practices can help to further our understanding of the ancient world in qualitative ways, not merely quantitative ones.

Sangro Valley Project: 1994-2010

The Sangro Valley Project was founded in 1994, and it is now managed by Oberlin College in collaboration with the Soprintendenza per i Beni Archeologici dell'Abruzzo and the University of Oxford. The project operates a summer field school in Italy for students from Oberlin, Oxford, and other institutions. The goal of the project is to characterize and investigate the nature, pattern, and dynamics of human habitation and land use in the *longue durée* within the context of a Mediterranean river valley system—the Sangro River valley of the Abruzzo region of Italy, which was the territory of the ancient Samnites.

As a regional project, SVP does not excavate at a single site. Instead, excavators move from site to site; the duration of study at each site depends on the amount of time required for a proper investigation, and in some seasons the project has been active at multiple sites. The project also employs pedestrian survey and other methods of data collection; therefore, the project's infrastructure needs to be mobile and flexible, and researchers cannot count on having access to anything other than what they bring into the field. Although SVP does have a well-equipped computer lab with an Internet connection in the dig house (generously provided by the town of Tornareccio), there is no Internet and no power in the field. These constraints did not pose much of a problem for paper-based recording, but they were to have a significant impact on the coming digital system.

Over its first 16 years, SVP employed various formats to record, store, manage, and analyze its data, as was common among archaeological projects active in the 1990s and 2000s (Ellis and Wallrodt 2011; Betts 2012; Houk 2012; Fee *et al.* 2013; Vincent *et al.* 2014; see Gordon *et al.*, Ch. 1.4; Sayre, Ch. 1.6; Wallrodt, Ch. 1.1). Excavation, survey, finds, and sample data were recorded on an array of paper forms in the field and in the lab, and the same information often needed to be recorded on more than one form. At the end of each season, these forms were scanned and transcribed into one of a number of digital formats that varied throughout the years (Microsoft Access, Excel spreadsheets, and fillable PDFs). Supervisors kept notebooks that were scanned at the end of each season but were never transcribed. Spatial data were gathered with a total station (for excavation) and handheld GPS units (for survey). These files were incorporated into a geographic information system (GIS) for spatial analysis, of which SVP was an early adopter (Lock *et al.* 1999; Bell *et al.* 2002). Drawings were done on Mylar sheets, which were eventually scanned and turned into digital vector drawings. Photographs were taken with digital cameras; despite being "born digital," they still required secondary processing. Supervisors were supposed to upload and caption their digital photos at the end of the day, but the process frequently was deferred for a day or two, and this delay of labelling the photos several hours or days after they were taken often led to errors. The dispersion and disconnection of our data made it very difficult to get a complete picture of all the information that existed for any given area or object; it promoted the introduction of errors in cross-referencing and labeling, and left the recognition of these errors to chance; and it caused supervisors to spend much of their time managing data rather than thinking critically about their trench, the site, or the region as a whole.

SVP 2011 Season

The opening of a new site in 2011 provided an opportunity to rethink how the project would collect and manage data for all future work. For years, the directors and staff of SVP had bemoaned the inefficiencies and mistakes that accompanied paper-based recording, of which we all had been both victims and perpetrators at various times. The obvious solution was always some sort of digital system, but nothing existed that met our needs until the iPad was introduced in 2010 (see Wallrodt, Ch. 1.1, who also makes clear that similar discussions had been taking place at other projects). The email exchange mentioned at the start, from March of 2011, was the culmination of a long search for a solution to what was, for us, a very real problem.

The paperless system that we employed in 2011 took an eclectic and somewhat fragmented approach, necessitated by the limitations of the software that was available in those early years of mobile app development (Motz and Carrier 2013). Rather than using one multi-functional app, we employed multiple pieces of off-the-shelf software (for off-the-shelf vs "bespoke" software, see Roosevelt *et al.* 2015; see also: Ellis, Ch. 1.2; Gordon *et al.*, Ch. 1.4; Sobotkova *et al.*, Ch. 3.2; Spigelman *et al.*, Ch. 3.4).

The heart of the system was a custom FileMaker database. The FileMaker platform combines moderate customization with high reliability and commercial support, making it one of the most popular choices among archaeologists (e.g., Jennings 2011; Houk 2012; Prins *et al.* 2014; see also: Bria and DeTore, Ch. 1.5; Ellis, Ch. 1.2; Spigelman *et al.*, Ch. 3.4; Wallrodt, Ch. 1.1; see below for many more options). All excavation data were captured in the field using FileMaker Go on iPads. In keeping with SVP's educational mission as a field school, students have always participated in the recording process—including photography, drawing, writing notebook entries, and filling out context, find, and sample forms—under the guidance of the trench supervisors, who were ultimately responsible for all field recording and still performed the majority of it. None of this changed with the adoption of iPads. Each trench was allocated only one iPad in order to avoid numbering conflicts and duplicate records. Due to the infrastructural constraints described above, data were stored locally on the individual iPads in the field rather than communicated directly to a central server.

The iPads were synchronized twice per day with a main database hosted on the project's local Mac mini server. This occurred when the teams returned to the dig house at lunch and at the end of the day, the same times when new finds and samples were brought in from the field. After the field data were synced with the server, specialists in the labs could then enter detailed information about the new small finds, pottery, and environmental samples, and this information would be available on the iPads after the next sync. The synchronization process that I used is not time-consuming (Wallrodt 2011a, 2011b), but it is complex and involves a series of steps that must be performed in a particular order by the database administrator (see below on the importance of documentation).

I also updated the project's field photography workflow, moving the captioning process out into the field in order to avoid the errors

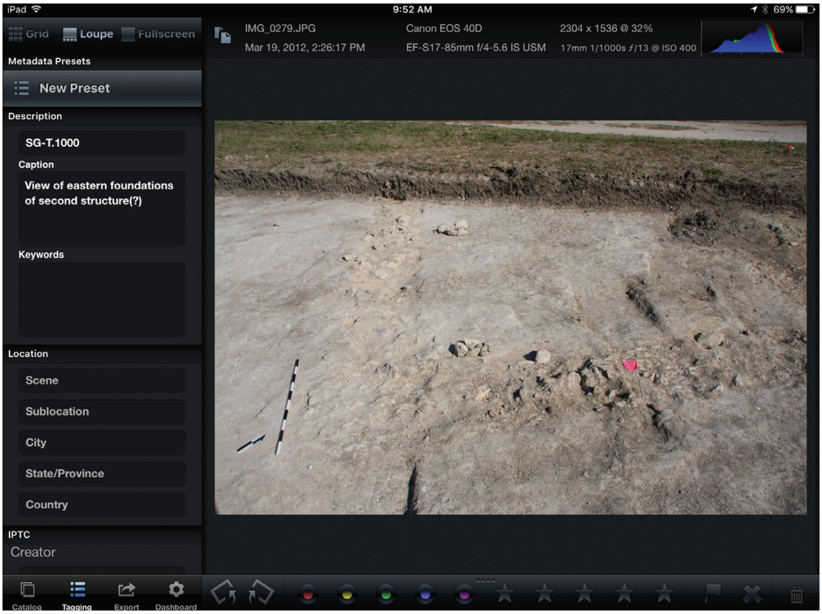
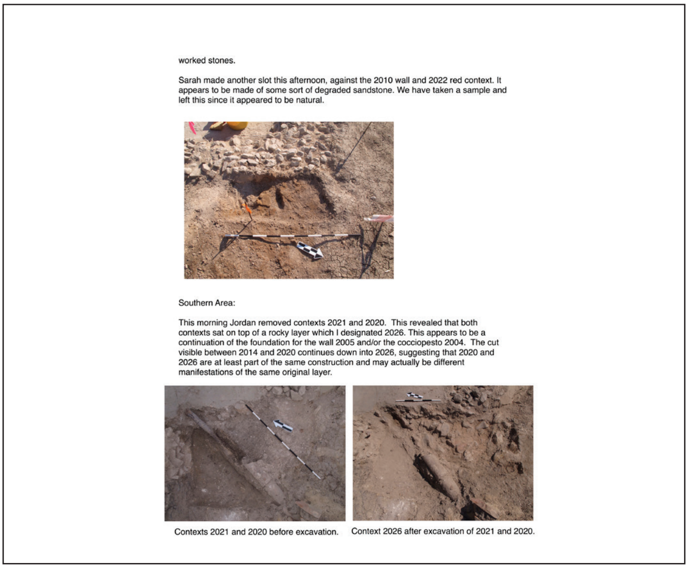


Figure 1: Photosmith iPad app.

from previous years. Excavators and surveyors used Eye-Fi cards, which are camera memory cards with built-in Wi-Fi. These cards were able to create their own ad-hoc networks, allowing them to send photos directly to an iPad—no wireless router or Internet needed. Field personnel then added captions and labels to the images' metadata using the Photosmith app on the iPad (FIG. 1). We used the "title" field for a structured subject code, while the "caption" field was for standard, plain-text descriptions. When the iPads returned to the lab, the labeled photos were uploaded to the server and imported into the database, where a set of scripts parsed the subject code to automatically link each photo with its subject record.

In addition to FileMaker and Photosmith, SVP used a handful of other iPad apps to assist with field recording. Several compass, calculator, and ruler apps were used in place of their more traditional counterparts, and a clinometer app proved particularly useful to the terrace survey team in measuring the approximate angles of slopes. Field notebooks were written with Apple's Pages program, which allowed excavators to integrate both drawings and photos into their accounts (FIG. 2). The project also used several drawing apps, but not in a systematic way. Supervisors were encouraged to experiment with different apps to find what worked best for them. We found that the vector drawing app TouchDraw was used most effectively for annotating and highlighting contexts in photos (FIG. 3) and for keeping running schematic plans that could easily be added to as the season progressed (FIG. 4); some supervisors used the program to draw measured sections and plans (FIG. 5). Simpler brush- or pencil-based apps were used frequently for quick sketches.

We identified numerous benefits to the paperless recording system used in the 2011 season: there was much quicker exchange of information between the field personnel and specialists; a significant decrease in human error through automation and controlled data entry; improved consistency of terminology through the use of pull-down menus and other structured fields; increased efficiency and time savings by eliminating the need to scan and digitize paper records; improved security of field data due to twice-daily syncing and backup; and an increase in the accessibility of information to all staff members, due largely to the fact that records could be accessed in both the field and the lab, whereas a paper record could be in only one place.



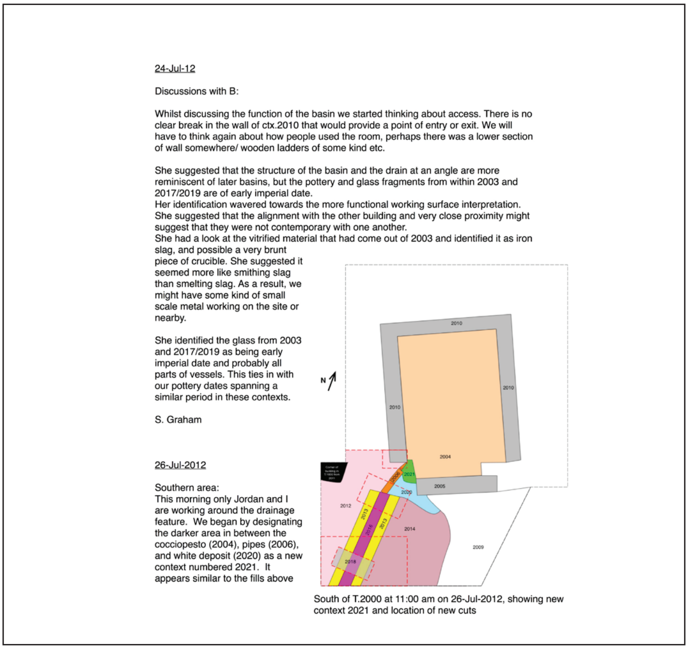
worked stones.

Sarah made another slot this afternoon, against the 2010 wall and 2022 red context. It appears to be made of some sort of degraded sandstone. We have taken a sample and left this since it appeared to be natural.

Southern Area:

This morning Jordan removed contexts 2021 and 2020. This revealed that both contexts sat on top of a rocky layer which I designated 2026. This appears to be a continuation of the foundation for the wall 2005 and/or the cocciopesto 2004. The cut visible between 2014 and 2020 continues down into 2026, suggesting that 2020 and 2026 are at least part of the same construction and may actually be different manifestations of the same original layer.

Contexts 2021 and 2020 before excavation. Context 2026 after excavation of 2021 and 2020.



24-Jul-12

Discussions with B:

Whilst discussing the function of the basin we started thinking about access. There is no clear break in the wall of ctx.2010 that would provide a point of entry or exit. We will have to think again about how people used the room, perhaps there was a lower section of wall somewhere/ wooden ladders of some kind etc.

She suggested that the structure of the basin and the drain at an angle are more reminiscent of later basins, but the pottery and glass fragments from within 2003 and 2017/2019 are of early imperial date.
Her identification wavered towards the more functional working surface interpretation.
She suggested that the alignment with the other building and very close proximity might suggest that they were not contemporary with one another.
She had a look at the vitrified material that had come out of 2003 and identified it as iron slag, and possible a very brunt piece of crucible. She suggested it seemed more like smithing slag than smelting slag. As a result, we might have some kind of small scale metal working on the site or nearby.

She identified the glass from 2003 and 2017/2019 as being early imperial date and probably all parts of vessels. This ties in with our pottery dates spanning a similar period in these contexts.

S. Graham

26-Jul-2012

Southern area:
This morning only Jordan and I are working around the drainage feature. We began by designating the darker area in between the cocciopesto (2004), pipes (2006), and white deposit (2020) as a new context numbered 2021. It appears similar to the fills above

South of T.2000 at 11:00 am on 26-Jul-2012, showing new context 2021 and location of new cuts

Figure 2: Portions of field notebooks written in Apple's Pages.

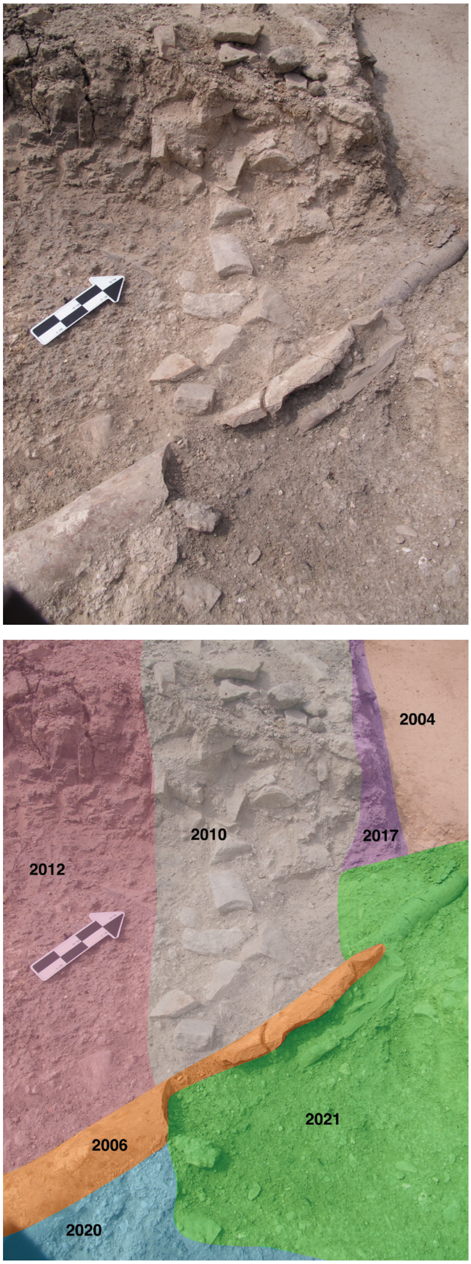


Figure 3: Example of a photo annotated with TouchDraw: original photo (top); annotated photo (bottom).

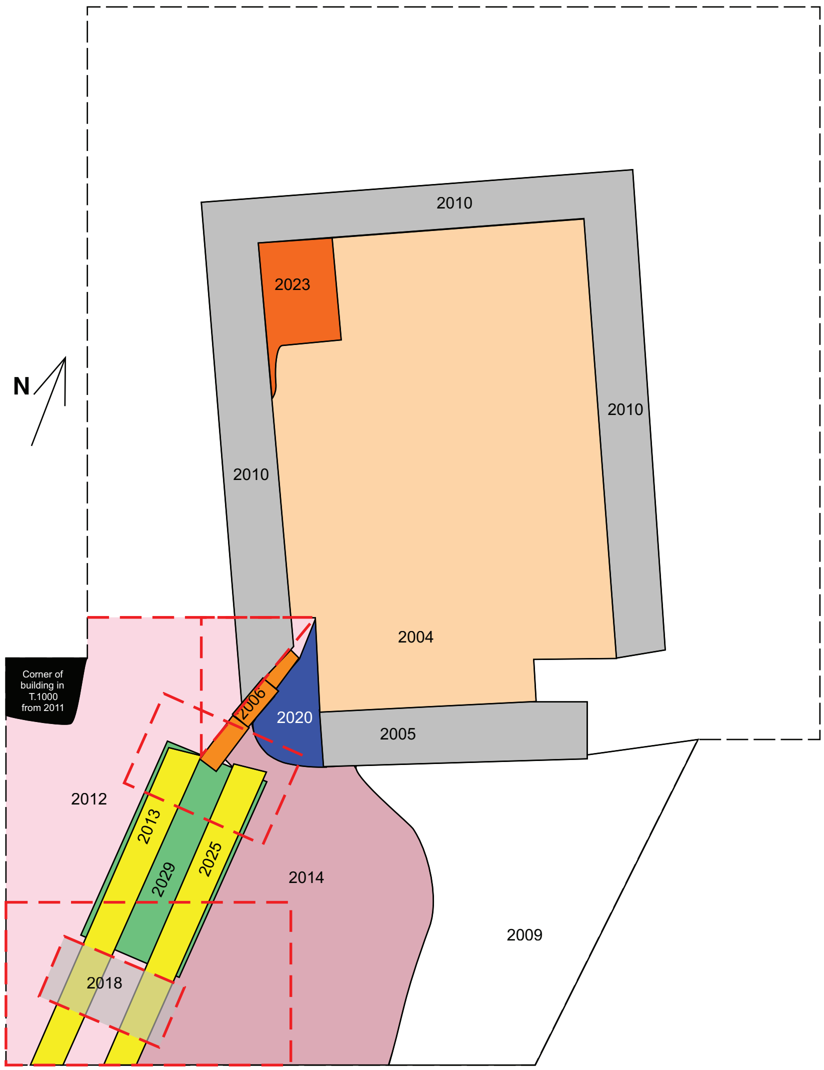


Figure 4: Schematic trench plan created with TouchDraw.

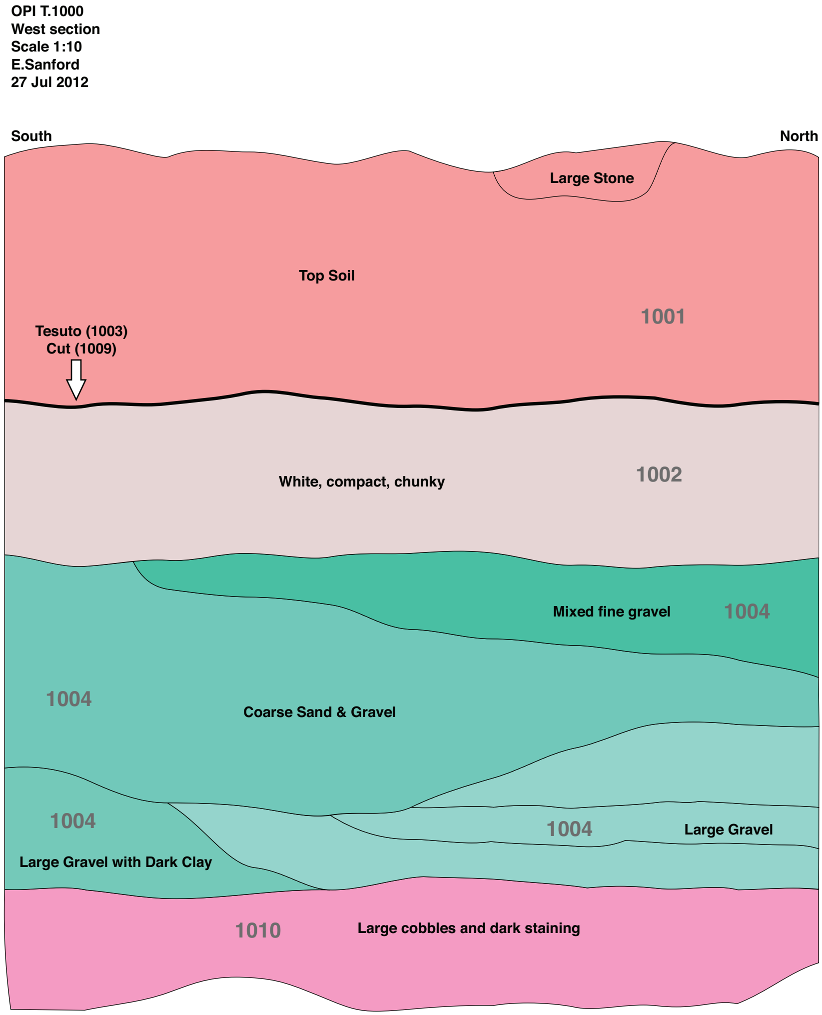


Figure 5: Measured section drawing created in TouchDraw.

SVP 2012 Season

I asked the staff for feedback after the 2011 season. Much to my relief, everyone felt that the hardware and software themselves worked well. Most of the problems the staff noted were related to how the project used its technology. My main goal for the 2012 season was to refine the existing paperless system and make it easier to use, with a primary focus on streamlining workflows and improving the database's user interface.

A key premise of the redesign was that field personnel are very busy and need to keep track of a large number of items and activities. Any work that could be offloaded onto the database would reduce the possibility of errors and allow the field personnel to focus on excavation and interpretation. For example, I had the database generate the carefully structured subject codes that we use to link a photo with its subject record. Instead of consulting a confusing text document to determine the correct format for labeling a photo, the supervisor simply opened the record for that subject on the database, tapped a new "camera" button in the lower left corner of the screen, and was presented with a pop-up that listed exactly what to type into Photosmith's "title" field (FIG. 6). Another task that was offloaded onto the database was object labeling. Every small find, bag of bulk finds, and environmental sample is supposed to be labeled in the field. Field personnel were traditionally assigned the burden of remembering what information was necessary for a variety of object types, along with the format for each label. Excavators inevitably made errors and omissions on their labels, and the task was complicated further by the 2011 version of the database, in which inconsistent layouts made it difficult to know exactly what information needed to go on a label and where that information was located (FIG. 7). To fix this, I centered the redesign around new "digital labels," which are directly analogous to the physical labels and which gathered all of the basic identifying information into the same place for each record type (FIG. 8). As was done in 2011, the excavator would create a record on an iPad when an object was found or a soil sample was taken, and they would then label the object by either writing on the bag or putting a piece of tape on a sample bucket (FIG. 9). But unlike before, all they needed to do now was look at the digital record they had just created and write exactly what they saw on the digital label. Because the find or sample was brought back to the lab at the same time as the iPads were synced, the project's specialists could immediately look up the new items and identify any errors or missing materials. And since the labels were written in a consistent way, it was much easier for the specialists to match the physical labels with the digital record. After adopting this method, the project has had far fewer mislabeled bags and orphaned objects. These changes to both photo and object labeling gave the excavators fewer things to worry about. The risk of "deskilling" here is minimal, since these are skills that few supervisors were able to master reliably (cf. Ellis, Ch. 1.2).

As these examples show, the design of a user interface can directly impact the effectiveness and efficiency of associated workflows. User-interface design and layout were considerations in the first version of the database, but my priority had been building a functional system. The result was aesthetically lackluster. Interface elements were scattered, and there was some organization, but the design was not consistent or intuitive, which made it harder to use. I felt that a better user interface would offer more than just aesthetic benefits, so I undertook a complete redesign for the 2012 season. A comparison of the original and redesigned versions of several screens illustrates the changes (FIGS. 10–12).

In order to produce more cohesive and intuitive user interfaces for SVP's 2012 season and for subsequent databases, I have routinely employed several design principles, of which I will highlight four. The first is to develop a consistent visual language. This can take many forms. For example, I used color coding to help differentiate between various data and interface elements. Each record type has its own color and these colors are consistent throughout the database. This means that when a user taps on the orange "Contexts" button in the top right of the home screen, the orange color persists throughout all Contexts screens, just as blue designates a Small Find and green designates an Environmental Sample (Supplementary Material 1).

The second principle is to utilize a clear organizational system. The more complex the database, the more important it is to have a simple and consistent layout and a clear navigational structure. I have dealt with this in two very different ways. When I began building SVP's system in early 2011, I simply copied the old paper system of

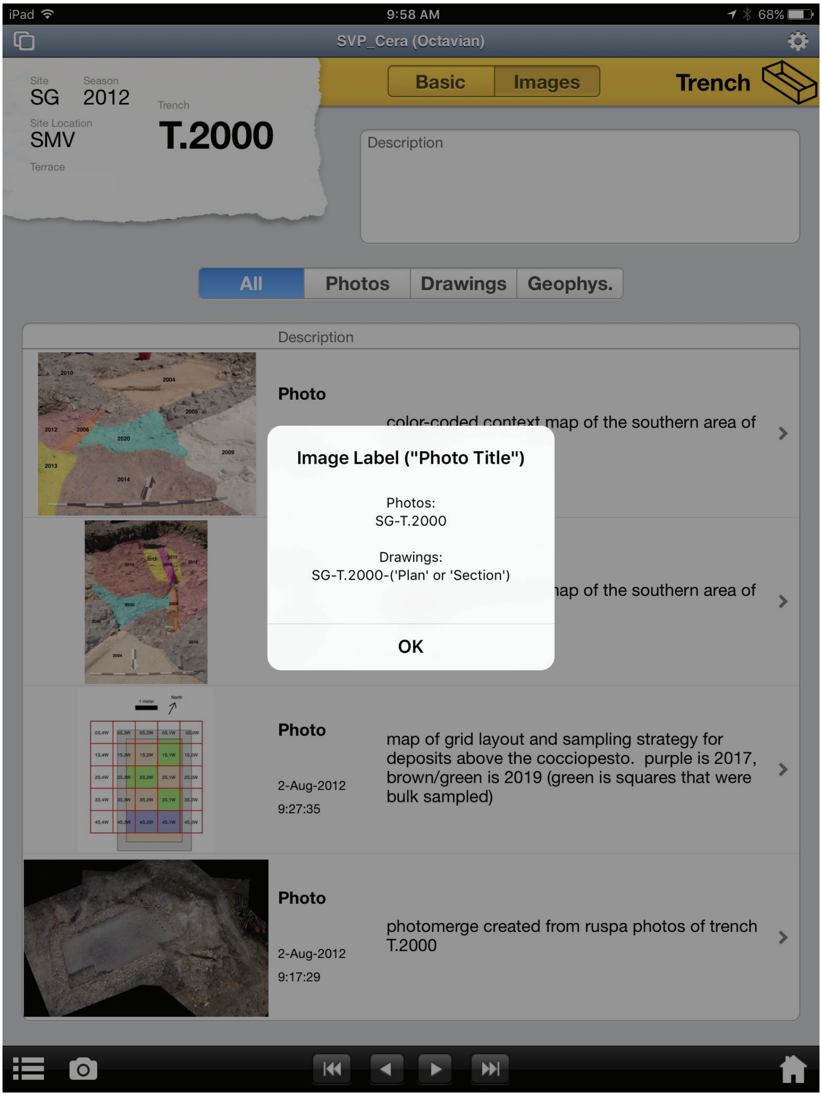


Figure 6: Image label pop-up.

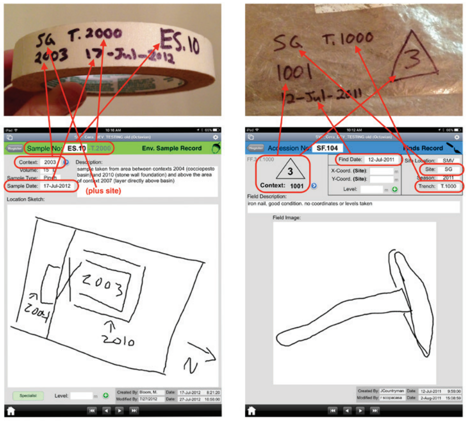


Figure 7: The original screens for environmental samples (left) and small finds (right), with arrows showing where information needed to go on the physical labels.

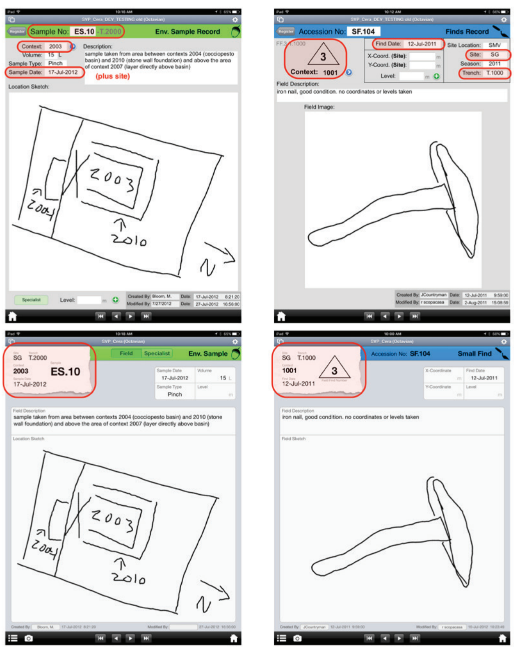


Figure 8: The original and revised screens for environmental samples (left) and small finds (right), with label information highlighted.

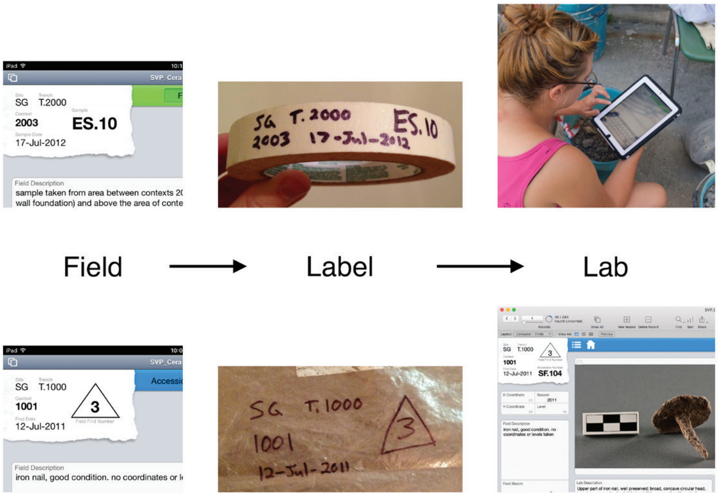


Figure 9: Examples of labeling workflows for an environmental sample (top row) and small find (bottom row): left) An excavator creates a record on an iPad; center) The excavator labels the object; right) Specialists view new items.

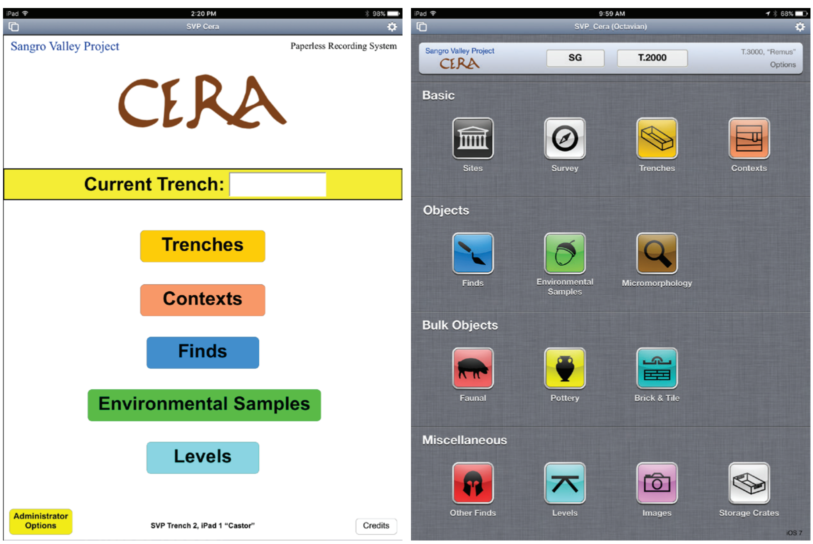


Figure 10: Examples of revised user interface, home screen: original (left); Revised (right).

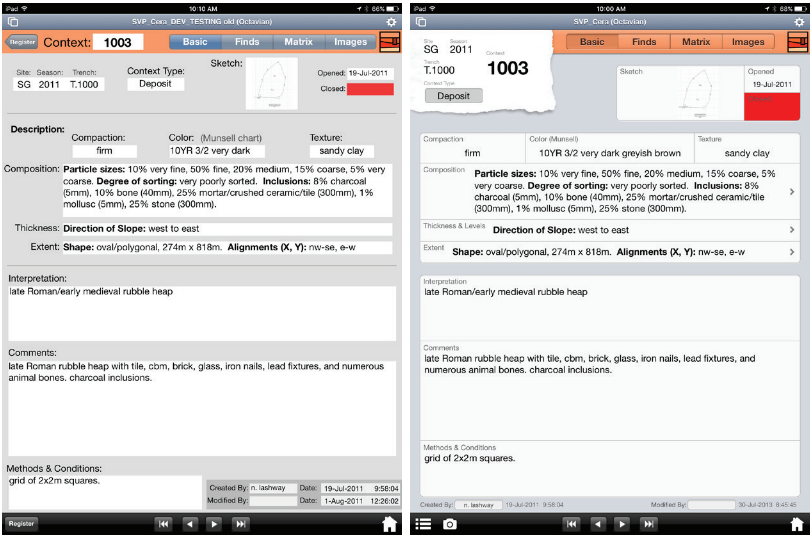


Figure 11: Examples of revised user interface, context screen: original (left); revised (right).

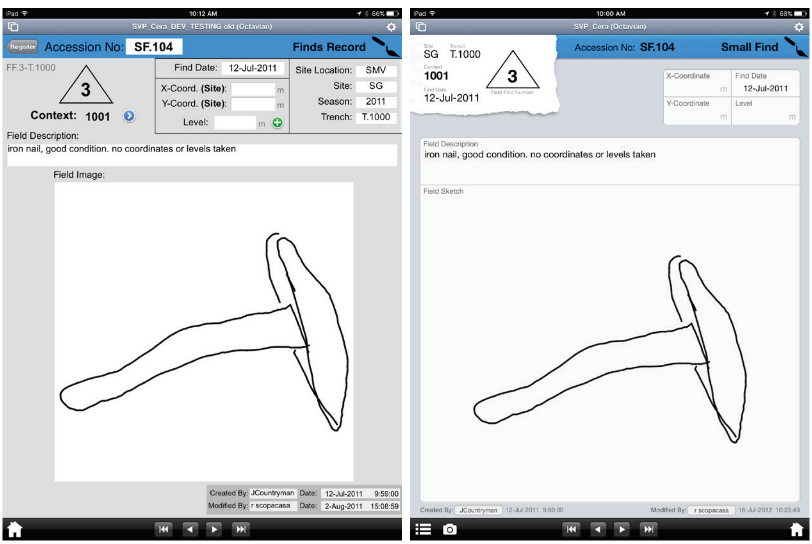


Figure 12: Examples of revised user interface, small find screen: original (left); revised (right).

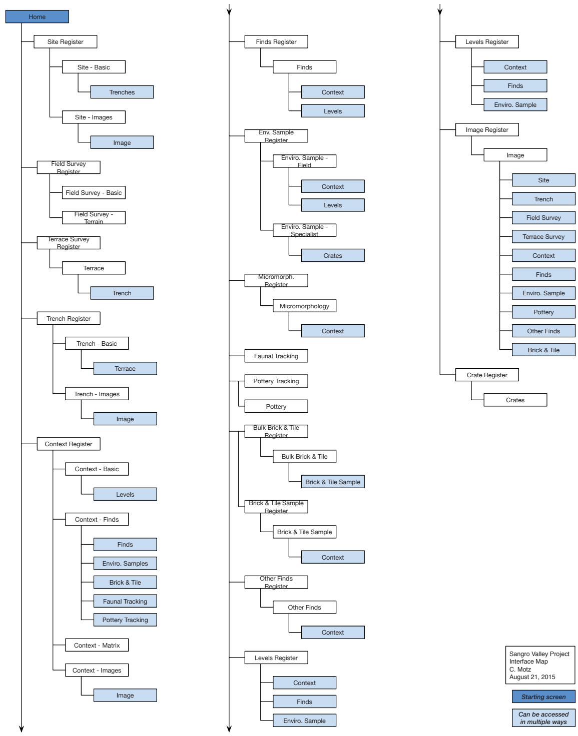


Figure 13: Interface map of the Sangro Valley Project database.

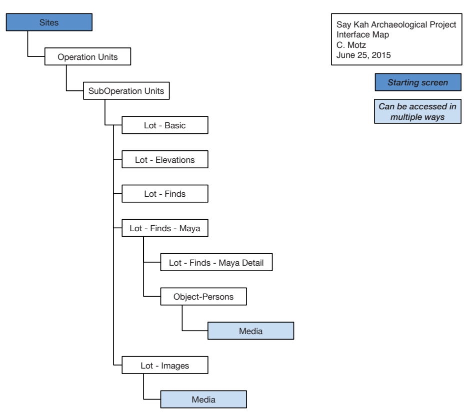


Figure 14: Interface map of the Say Kah Archaeological Project database.

registers and records that I was familiar with from previous seasons (cf. Wallrodt, Ch. 1.1), which resulted in a compartmentalized navigational structure that does not reflect how sites, trenches, contexts, and finds are related to each other (FIG. 13). When I started working on the SKAP database in 2014, I wanted to try something different. For SKAP I adopted a linear navigational structure that mirrored "real" data hierarchy and relationships (FIG. 14). In this model, the user navigates back and forth along a single "line" of data, drilling down into smaller analytical units or pulling back out to see larger ones. Both approaches have their pros and cons, but I think that the latter is better overall, helping to keep clear the relationships between different elements in the data structure, as well as the relationship between the data structure and the physical world.

The third design principle is simplification. Different actors in the research process often need to see different information about the same items. When an excavator enters a new small find, all they need to record is a brief description, a sketch, the object's location, and their name (FIG. 15A). The finds officer needs both to see all of the data recorded by the excavators and enter much more detailed information, but I keep the field and specialist data visually separated (FIG. 15B). Rather than showing everything to everybody and falling prey to the ever-increasing "data avalanche" (Kansa 2011: 1–2; Levy 2014; Huggett 2015b), I show each person only what they need and make clear the respective origins of the different pieces of data.

The fourth and final user interface element that I have found helpful is automation. As I mentioned above, having the database automatically enter information and perform certain tasks frees staff to focus on excavation and analysis. In addition to directly entering data (tasks like numbering new records, linking them to the correct trench or context, or entering the date), I would include under this heading those automated tasks that do not *directly* enter data but do make life easier in other ways, such as the generation of image codes that I discussed earlier. Another example of this comes from SKAP. When a SKAP supervisor enters or changes an excavation unit's datum and trench orientation, she or he is provided with a visual representation of the trench's position (Supplementary Material 2). This information is also displayed on the context screen in order to help excavators orient themselves when recording the thickness at various points in the context. This automated and responsive interface element helps to ensure that elevations are recorded in the correct location.

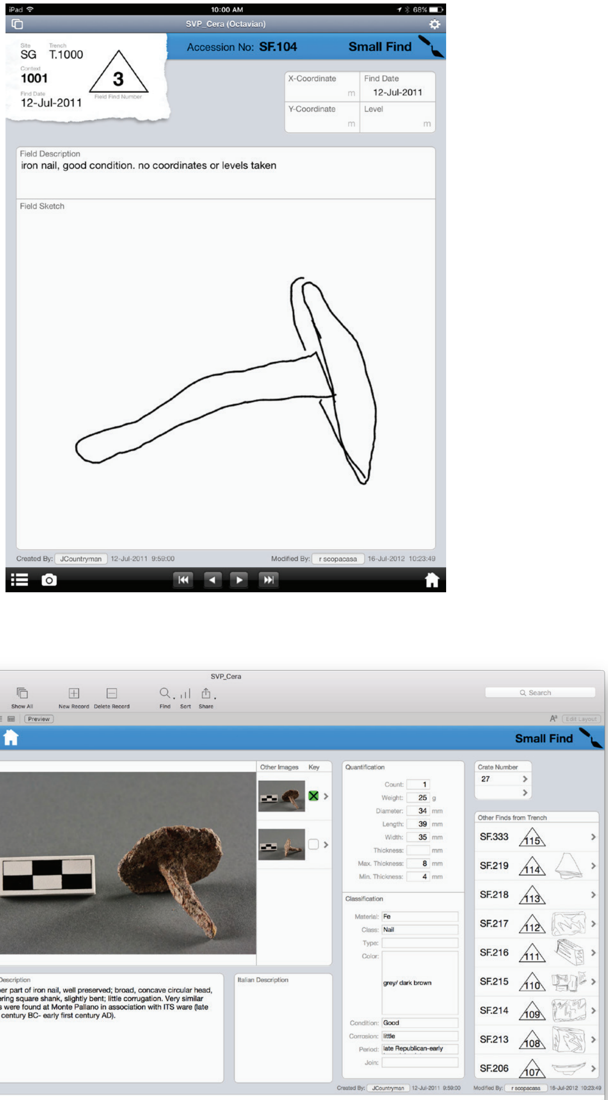


Figure 15: Different views of small find data: iPad layout for excavators (top); computer layout for specialists, with the field data circled in red (bottom).

SVP 2013 Season

Due to the success of the redesign, the SVP database has remained largely static since 2012 except for occasional bug fixes. In 2013, however, I began working with the Pompeii Archaeological Research Project: Porta Stabia, whose seasons always coincided with those of SVP. This meant that I would no longer be able to run SVP's system during the field season. Therefore, we needed to find and train my replacement. We were fortunate enough to be contacted by a Master's student from Lund University, Luke Aspland, and we enlisted a SVP alumna, Miriam Rothenberg, now a Ph.D. student at Brown University. I began training Miriam and Luke by email and Skype during the winter and spring of 2013, and we met for a week of intensive training in Oberlin, Ohio, in early May.

The three of us quickly discovered that much of the understanding of how to run the paperless system existed only in my head, so I decided to create a set of documentation. As I outlined at the beginning of this paper, the database was in a state of semi-completion when SVP's 2011 season began. The project had decided to go paperless only in March 2011, and the dig season began in early July, so the development and testing process was rather rushed. When excavation began in early July, all of the most critical elements were mostly functional and mostly stable, but I continued to refine, fix, and add numerous elements throughout the season. Due to the incomplete nature of the system, as well as my inexperience in running anything like it, producing documentation was a much lower priority than producing a fully featured and stable recording system. The highly fluid and evolving nature of our procedures and of the database itself added further barriers to generating documentation. It was not until the middle of the second season, when the system had reached a point of stability, that writing a user guide appeared on our radar screens.

In hindsight I wish that I had produced such documentation earlier, because it would have made the job of running the paperless system much less stressful for the first two seasons. The more elements you add to something—the syncing, the image handling, the various pieces of hardware and software—the more difficult it becomes to keep it all straight in your head, let alone to hand off the system to someone else. In addition to a user guide, we created several types of documents

Database Syncing Procedures

1	**Make sure no devices are connected to Parent DB (Server) and that they remain disconnected until entire syncing process is completed**
2	**Close Parent DB (Server)**
3	**Make backup copy of Parent DB** (Public / Database / Backups / SVP Cera Backups)
4	**Reopen Parent DB**

5	**Close Child DB (iPads)**
6	**Copy Child DB from iPad to server** (Desktop / Incoming Databases)
7	**Sync Child DB with Parent DB** (0_0_2 Run All Sync Scripts)
8	**Rename Child DB and move to backups folder** (Public / Database / Backups / SVP Cera field Backups)
9	**Repeat for all database iPads**

10	**Close Parent DB**
11	**Copy DB onto iPads** (from Public / Database)
12	**Charge iPads**

13	**Reopen Parent DB**
14	**Tell specialists they can connect again**

Notebook Syncing Procedures

1	Open Pages, make sure notebooks have all synced via iCloud

Sangro Valley Project 2013: Syncing Workflows

Figure 16: Checklist of syncing procedures.

Event	Result	Solution
New on child	Import into parent	
New on parent	Stays in parent	
New on both (same number)	KEEPS BOTH	Manually resolve the conflict AFTER sync
Changed on child	Updates in parent	
Changed on parent	Stays in parent	
Changed on both	Dialogue box, conflict resolution screens	Manually resolve the conflict DURING sync
Delete existing on child	Stays on parent	Manually delete from parent
Delete existing on parent	Remains deleted from parent	
Delete existing on both	Remains deleted from parent	

Sangro Valley Project 2013: Syncing Event Matrix

Figure 17: Chart of events that can occur during syncing.

that have proven particularly useful. The first of these were files documenting the syncing process, which always has been complex. One file was a checklist of all of the steps involved in syncing the database and notebooks (FIG. 16); the other file was a chart covering everything that can occur while syncing the database, along with what the result is and what action needs to be taken, if any (FIG. 17). Another set of documents were workflow diagrams. One workflow presents all the steps for image processing, which was used mainly by the database administrator and the photographer (FIG. 18). Another diagram charts the steps involved in recording and processing various object types and samples recovered during excavation (FIG. 19). We found that by creating these workflow diagrams we were better able to communicate to various staff members how their physical tasks integrated with their database tasks and how their role—be it field or lab—fit into the workflow as a whole. I made a point of generating similar documents during the development of the SKAP database, and, as a result, the system has been much more manageable in its first season (2015) than the SVP database was in either its first or second seasons.

Problems and Recommendations

In addition to the discussion above, I would like to offer three recommendations for improvements to workflows based on observations I have made while working with these three projects. First, proactive communication with all staff members and users of the system is critical, especially in the first season or two and especially with users who are new to the system. Many people do not realize that the system can be changed to fit how they work, and they often do not bring up problems that arise because they do not realize that they can be fixed. Several times users have assumed that they had to change how they worked to fit the database, which often results in ad hoc, improper, and inadequate solutions to easily solvable problems. For example, if a field did not already exist, very often users would type descriptions or additional information into whatever field they thought was appropriate, rather than asking for a new field. Another example of an easily solvable problem is the tab order, or the order by which the cursor moves through fields when the user presses the "Tab" key; several times I have discovered that an unexpected tab order—which

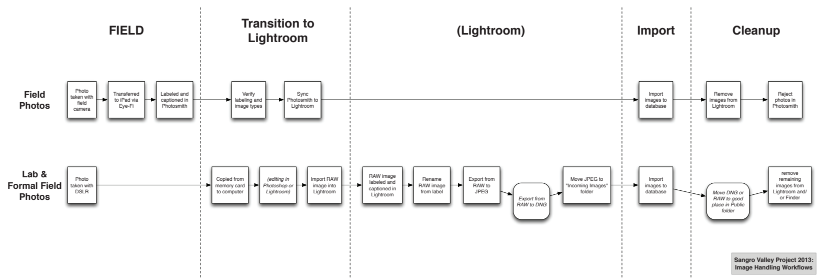


Figure 18: Image handling workflows.

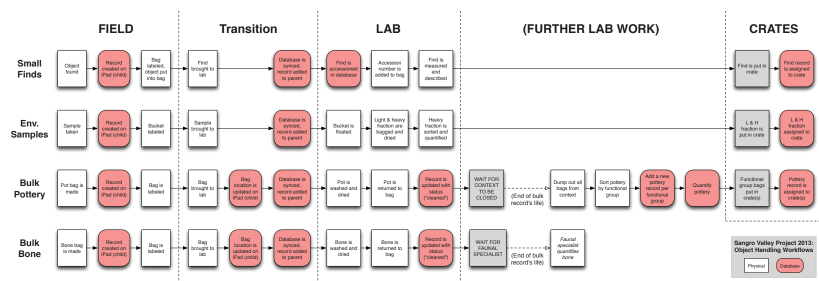


Figure 19: Object and sample handling workflows.

can be fixed in about 30 seconds—had been slowing down users for days or weeks before it came to my attention. This was especially troublesome during the study seasons at PARP:PS (2013–2015), when team members were engaged in the industrialized task (Caraher 2013; Ch. 4.1) of processing large volumes of materials. I suspect that this common user behavior—or more accurately, lack of behavior—is a symptom of most people's experiences with computers and software being a passive one. For example, users do not get to change how Microsoft Excel works. Fortunately, this function is easy for a developer to remedy by actively seeking feedback from users. In my experience, users quickly learn that the system can be changed, and before long they will offer suggestions and ask for changes without prompting.

Second, everyone must remember that the database administrator and/or developer is a member of the excavation team and a partner. It is important that the developer understand how each person works and how that fits into the database and the entire recording process, and it is important that each project member understand how they fit into the process so that tasks or objects do not fall through the cracks (see Holtorf (2002) and Yarrow (2008) on some interpretive implications of archaeological workflows). Diagrams and flowcharts are helpful in this but there are a range of ways to accomplish this goal, including building progress bars and trackers. For example, I have built for SKAP some digital flags that get raised depending on certain actions: an excavator can check a box if a find needs to be photographed or examined more closely, which triggers a visible flag in that find's parent records (Supplementary Material 3). These flags help both excavators and specialists keep track of what objects need further attention.

Third, there are things that the administrator or developer can do to ensure that the system will run smoothly no matter who is in charge. As I mentioned above, a user guide is useful for training field staff, and documentation of the inner workings of the system is useful for both current and future administrators. While paperless systems are effective, they are not yet simple to run. Furthermore, a description of the recording system's technical details should be included with other metadata in any final repository or publication to aid in the contextualization of the data that it helped to produce (Atici *et al.*

2013; Kansa and Kansa 2013). Documentation is essential at all stages of the research process.

I will return for a moment to my first two recommendations, which highlight what I see as the central place of the database administrator or data manager within a web of team members. Other contributors to this volume (Caraher, Ch. 4.1; Ellis, Ch. 1.2; Wallrodt, Ch. 1.1) touch on the role of digital technologies within the structures of archaeological projects, but the digital technologists themselves have been considered only tangentially. We would be wise to confront more directly and comprehensively how databases and data managers should fit into the broader communication and social networks of a project (Berggren and Hodder 2003; Frankland and Earl 2014; see also: Roosevelt *et al.* 2015 on using technology to facilitate intra-team communication), but this issue deserves a fuller exploration than can be contained in this chapter.

Many of the problems that I have presented are not unique to paperless projects, but digital recording systems make you aware of them and force you to confront them much earlier (for a debate on the perpetual fallibility of archaeologists regardless of recording media, see Caraher 2013; Ch. 4.1; Ellis, Ch. 1.2). When designing paper forms, for example, you do not have to be explicit in how the different parts relate to each other. When you design a relational database, you do have to be explicit in this (see Wallrodt, Ch. 1.1, on joining the "pieces" of data). The same underlying problems and needs still exist in both cases. However, with traditional methods you may not realize that you have a deep problem with your data structure or procedures until it comes time to analyze the data.

The technological landscape has changed in the last five years, yet the early lessons retain their value as a second generation of paperless projects is born. Early adopters like PARP:PS, SVP, the E'se'get Archaeology Project (Betts 2012), the Chan Chich Archaeological Project (Houk 2012), and the Pyla-Koutsopetria Archaeological Project (Fee *et al.* 2013; Fee, Ch. 2.1) were converts from paper, and their use of digital recording relied on incremental translations of existing practices in order to maintain internal consistency. Now, new projects like SKAP and the Kaymakçı Archaeological Project (Roosevelt *et al.* 2015) are being conceived as paperless from the start. This freedom from existing legacy data and procedures has allowed scholars the flexibility to redesign completely their archaeological workflows and data structures, with exciting results (Roosevelt *et al.* 2015; Jackson *et al.* 2016). At the same time, the development of commercial or open-source archaeological software, which previously had focused on data analysis and dissemination, has turned increasingly toward field recording on mobile devices (e.g., ARK (Dufton, Ch. 3.3), Codifi (Prins *et al.* 2014), FAIMS (Sobotkova *et al.*, Ch. 3.2), iDig (Hartzler 2015), OpenDig (Vincent *et al.* 2014), and TooWaste (Castro López *et al.*, Ch. 3.1)). Archaeologists now have a higher number and higher quality of digital tools to choose from, and I am excited to see what comes next. Amid the often dizzying pace of technological innovation, I urge that we maintain a goal of creating digital solutions that play nicely with human team members and with the physical aspects of fieldwork.

Efficiently Slow Archaeology

Paperless systems are becoming more widespread and they are already revolutionizing the way archaeological data are collected, managed, and analyzed. However, these developments have not gone unquestioned (Huggett 2015a; Nakassis 2015). Many of the critiques—in particular the recent push for "Slow Archaeology" (Caraher 2013; Ch. 4.1)—force us to consider our reasons for adopting new technology and the benefits that we gain from employing it, and they thus serve a useful role in checking the blind adoption of technology for its own sake (Ellis, Ch. 1.2).

I agree with many of the arguments extolling the virtues of careful, thoughtful practice, and I believe that digital recording can promote such practice. I suggest that while some aspects of field recording do require careful thought and attention, not every recording task is equally deserving. The focus of Slow Archaeology on drawings and notebooks, two distinctly non-repetitive activities, supports this implicitly (Caraher 2015b). Much of the time savings found in paperless systems are gained by eliminating the repetitive tasks inherent in the form-based recording of a modern "industrialized" (after Caraher) archaeological project, and by centralizing tasks that otherwise would be spread across multiple sheets of paper and notebooks. Supervisors can spend a surprising amount of time manually numbering stratigraphic units and small finds, tracking bags of materials from the field to the lab, adding up sherd counts, and ensuring that any changes to recorded data are updated in all the relevant forms and notebooks. A computer is able to perform these jobs more quickly and (perhaps more importantly) more reliably than a human. Forcing a supervisor to expend considerable energy on these repetitive tasks can promote their perception of the archaeological remains as a fragmented data set that consists only of identification codes and quantifications. By shifting much of this burden, the efficiency of digital recording can help to achieve some of the goals of Slow Archaeology while still meeting the expectations of modern archaeological practices (cf. Caraher 2015b).

At the end of the day, paperless recording is merely a tool, and it is up to us to decide how to use it. The time that excavators save with an efficient paperless system can be used in a myriad of ways: they can put more time into drawings or produce more of them; they can spend more time teaching field school students, something that digital systems can both facilitate and complicate (Opitz 2015; see also Bria and DeTore, Ch. 1.5); they can excavate with their own hands, which many supervisors yearn to do more and which can improve their understanding of a site; and yes, they can simply gather more data (Caraher 2015a; 2015b; Ch. 4.1; Nakassis 2015; Roosevelt *et al.* 2015; Ellis, Ch. 1.2). But these digital systems also open up exciting possibilities for new interpretive approaches (e.g., Roosevelt *et al.* 2015).

For example, during the 2015 season of the Say Kah Archaeological Project, we used our paperless system to include different world views in the recording process (Jackson *et al.* 2016). One of the goals of SKAP is to recognize and decenter the dominance of modern, Western archaeological visions of the material record, in order to make space for Classic Maya understandings of the material world. A digital recording system can seamlessly switch between different ways of viewing data. This flexibility enabled us to integrate emic views in the recording process, and to give equal footing both to Western, dualist ways of reading the archaeological record and to indigenous Maya understandings of this material. Our excavation permit from the Belize Institute of Archaeology and the umbrella project under which we work, the Programme for Belize Archaeological Project, mandated the submission of particular forms with the final report. Similar reporting requirements often are cited as a barrier to the full adoption of digital archaeology in some sectors, but in many cases these can be overcome easily by creating layouts that replicate the required forms for printing, or saving PDFs, as we did (see Spigelman *et al.* (Ch. 3.4) for an example of success within cultural resource management, but cf. Dufton (Ch. 3.3) on operating within the constraints set by the City of London). Using a digital recording system allowed us to meet these recording requirements while also collecting additional types of data, but without the increased workload and conceptual divide of two physically separate forms. The efficiency we gained by transitioning to digital recording freed both time and space for excavators to turn their attention to the additional types of data that we are collecting; the increased efficiency directly facilitated the addition of these new elements. Our experience indicates that paperless systems allow for nimble movement between multiple ways of seeing and recording, a capability that can radically shift our understanding of archaeological sites and materials even while in the field, allowing interpretive insight to occur simultaneously with the excavation process and in-field planning and execution.

Conclusion

The community of paperless projects has grown quite a bit since 2010, as has the community of people developing paperless recording systems. This volume is evidence of that growth. There are now many more resources available to those who are developing apps and databases for tablets: Apple provides excellent documents like the "iOS Human Interface Guidelines," FileMaker has posted videos and a variety of guides, and countless websites offer resources both for general mobile development and that specific to FileMaker. The lessons that we learned in those first few years, however, are still valuable, and it is from that perspective that I have tried to offer some insight into building an effective paperless archaeological recording system.

We as archaeologists should no longer be satisfied with just getting a paperless system to function successfully—although that is certainly no small feat. We need to continue experimenting and thinking about how to make these systems work as an integral part of the research process. It is not enough for developers or administrators to possess technical skills; they need to have visual design skills and to be able to communicate effectively through the system. They need to work *with* specialists and excavators, not be tyrants. Digital recording systems can streamline fieldwork, improve the quality and quantity of data collected in the field, significantly reduce errors and misunderstandings, and facilitate new interpretive approaches, but they do require careful and thoughtful preparation and implementation. I hope our experiences will help others to implement paperless recording systems successfully within their own projects.

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