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TESTING IPAD IN THE FIELD: USE OF A RELATIONAL DATABASE IN GARBOLOGICAL RESEARCH

ABSTRACT: Recording thousands of entries during field research poses a challenge to any field researcher. Contemporary handheld computers offer affordable solutions, which can resolve this challenge. In this paper, we test the iPad tablet computer and FileMaker Go database to conduct garbological research carried out in West Bohemia (Czech Republic). Garbological research based on the collection of data about human waste requires not only efficient tools for recording a vast number of individual garbage items on the spot but also integration of multiple analytical levels in a database. Our research was aimed at household waste to illuminate consumption patterns and mobility of humans and things in contemporary Central European settings. The iPad was used to collect textual and visual data and integrate these in a relational database. We describe our methodology and experience with this kind of technology. The iPad and FileMaker Go proved to be well suited to challenging field conditions in the landfill, data collection was efficient and reliable, the database was flexible because its basic features could be modified in the field, and one could even examine preliminary trends in the data using charts in FileMaker Go. The proposed hardware and software is less efficient for the collection of precise spatial data, preparation of accurate drawings, and for projects in remote areas without good access to an electrical grid.

KEY WORDS: Data collection – Digitization – Garbology – Handheld computer – Rubbish – Tablet computer

INTRODUCTION

Handheld computers have expanded into a multitude of spheres in the contemporary world. One encounters their users in buses, at cafés, airports, or increasingly among social and natural scientists. There have been a number of debates on the advantages and disadvantages of handheld computers in educational and academic settings (Kho *et al.* 2006, Kim *et al.* 2009, Ward, Tatsukawa 2003). Less attention, however, has been paid to the new range of possibilities for field research. Field research in anthropology represents a domain that can benefit greatly from the application of handheld computers, and in particular when combined with

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relational databases that provide powerful tools for the collection and organization of data (cf. Bernard 2006: 410, Fischer 1994: 31). The efficiency of collection and handling of the data challenges the traditional pen-and-paper approach where researchers enter data into various paper forms in the field and then spend several months digitizing the data. Moreover, contemporary database software supports integration of different kinds of data such as text, audio, and video in a single environment and creation of links among different aggregations of data (Annechino *et al.* 2010, Harrington 2009). Although the use of handheld computers and direct digitization of data in the field has some drawbacks, we argue that the advantages prevail and devices such as iPads powered by relational databases or other data oriented applications have great potential for data collection in a range of field projects.

The application of computers in field research in the social sciences goes back to the late 1970s (see Fischer 1994: 67 for review). Initial attempts were associated primarily with computer-assisted personal interviewing (CAPI), which enhanced the ability of a researcher to collect structured data efficiently and systematically (Baker 1992, Bastelaer *et al.* 1988, Saris 1991: 5–6). Computers have been used successfully for various field projects in the social sciences where archaeological excavations (Lock 2003, McPherron, Dibble 2002, Searcy, Ure 2008, Stewart, Johnson 2011), structured interviewing (Childs, Landreth 2006, Galvez *et al.* 2009, Gravlee 2002, Kissinger *et al.* 2010) or observations (Gravlee *et al.* 2006) took place. Indeed, Greene demonstrates the advantages of handheld computers for writing quick field jottings and he reports that such devices enabled him to take notes 176% faster than with pen and paper (Greene 2001: 186). On the substantial level, the digital form of data collection yields comparable results to paper forms. The reported agreement between the data collected with the classic pen-and-paper approach and handheld computers reaches beyond 95% (Fletcher *et al.* 2003: 171).

Handheld devices for computer-assisted data collection have undergone considerable development recently. While the early attempts to use computers in the field took advantage of notebooks or even larger devices (de Leeuw, Nicholls II 1996), smaller handheld devices with keyboards began to appear in the mid-1980s, and units incorporating touch screens began to dominate at the beginning of the 21st century (Gravlee 2002, Greene 2001). Contemporary handheld devices can be used for many hours without charging the battery and integrate various functionalities such as text, audio, video, and photo recording, geographic tools, wireless connectivity, and data synchronization. Therefore, for a researcher in the social sciences and humanities handhelds represent devices for data collection, storage, analysis, presentation, and sharing.

We tested the tablet computer for an anthropological research project focused on material objects in contemporary society. This research builds primarily upon the tradition of garbology that examines human refuse to understand human behavior (Rathje 1984, Rathje, Murphy 2001, Shanks *et al.* 2004). Recent works (e.g., Gille 2010, Gregson 2007, Gregson *et al.* 2010) have moved even further to open new conceptual and theoretical topics inspired by studies of materiality (Ingold 2007, Miller 2005). The garbological analysis of material manifestations of human action represents a critical feedback for other kinds of research that rely on the data about what people do and what they say they do. Our research focused on household waste from two urban quarters in the Pilsen region in the Czech Republic to examine households' preferences of certain commodities, brands, amount of resources wasted, and mobility of humans and things (Brunclíková, Sosna 2012, in press).

In this paper we present firstly an overview of computer-assisted data collection (CADC) in garbological field research. Secondly, we report our experience with the iPad tablet computer combined with the Filemaker database software during field research in a landfill where we digitized data about individual items and samples of garbage. Thirdly, we discuss the way we integrated textual and visual data into a relational database, which provided an environment for data collection, storage, and preliminary analysis in the field. Finally, the pros and cons of using an iPad tablet in field research are discussed.

MATERIAL AND METHODS

Data collection took place in the Chotíkov landfill, ca. 4 km from Pilsen in West Bohemia, Czech Republic. Two main random samples of buildings (N_{m1} = 19, N_{m2} = 21) from two urban quarters were selected and garbage from the containers, which were associated with the selected buildings, was transported to the landfill by a standard garbage truck. Garbage represented household waste, which was deposited into the containers within a period of four days in late July 2012. In the landfill, we created a fenced research area covered by a large tent. Each main sample of garbage was stirred up with

FIGURE 1. Tablet used for data entry in the field. Photo by A. Becková.

a loader to increase its internal heterogeneity and prepare it for next step of sampling. After that, we took subsamples ($N_{s1} = 5$, $N_{s2} = 6$) from the main samples to reduce the amount of material that three researchers would process during four weeks in the field. A subsample equaled the amount of garbage necessary to fill a large dustbin (120 liters). We divided each main sample into quarters and took garbage for a single subsample from two opposite quarters until the sampling dustbin was full. After the filled dustbin was weighed, garbage was poured out into a sieve and two researchers started sorting. During the field season in 2012 we described in detail and digitized 136 kg of garbage, which contained 3317 individual items.

Data was recorded into an iPad 2 (16 GB, Wi-Fi) tablet computer (*Figure 1*, *Table 1*) powered by a FileMaker Go 12 database, which was developed for mobile devices specifically. There were a few reasons for selecting this hardware and software. We had very good previous experience with FileMaker Pro in OsX environment from previous archaeological projects, iPad with iOS represented a good choice in terms of compatibility with our MacBook Pro, and we simply

TABLE 1. Field equipment used for data recording, analysis, and storage in the garbological research.

Field equipment	Number of items	Cost per item (EUR)
iPad 2 16 GB Wi-Fi (tablet)	2	430
Filemaker Pro 12 (desktop software, requires a desktop or laptop computer)	1	220[a]
Filemaker Go 12 (iPad application)	2	Freeware
MacBook Pro (laptop computer)	1	1100
WD external hard drive 1 TB (data storage device)	1	120
Field notebooks	4	5

[a] Pricing for educational and non-profit institutions.

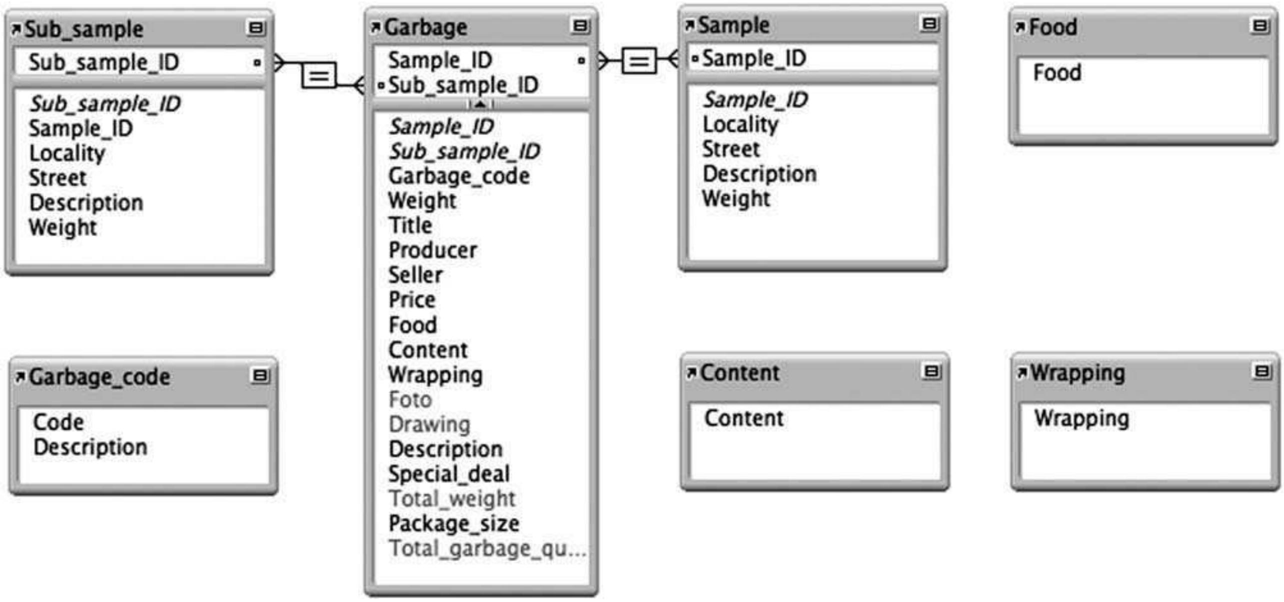

FIGURE 2. Relations among the tables in the database.

believed that a tablet produced by Apple will be durable and functional in the field.

In FileMaker Pro 12 – the software version for desktop and laptop computers – we created three main tables for three basic analytical levels; main samples, subsamples, and garbage items. Another four tables served as sources of categories for specific fields in database layouts. The tables were linked using software facilities for establishing associations based on relational logic (*Figure 2*).

The layout for individual items consisted of two main parts; the first part was designed for textual and the second for visual data. Fields for textual data included ID, date and time of entry and last modification, association with a sample and subsample, name of the item, its weight, information about the producer, seller, price and discount, nature of packing, presence of residues, notes, and the category into which the items fall. Inspired by Rathje and Murphy's (2001) approach to classification, we developed 150 specific categories of garbage (e.g., butter, cable) that were lumped into more general categories (e.g., milk products, electronics). FileMaker enabled us to create a drop-down menu with categories of garbage accompanied by numeric codes (*Figure 3*). Visual data was recorded directly into the database (*Figure 4*). When one taps the picture field on the tablet's screen, FileMaker Go enables one to activate the integrated camera and take a picture of an item. The picture is linked to other kinds of information of the same record in the database.

Layouts for samples and subsamples were less elaborate and included basic descriptive data about the

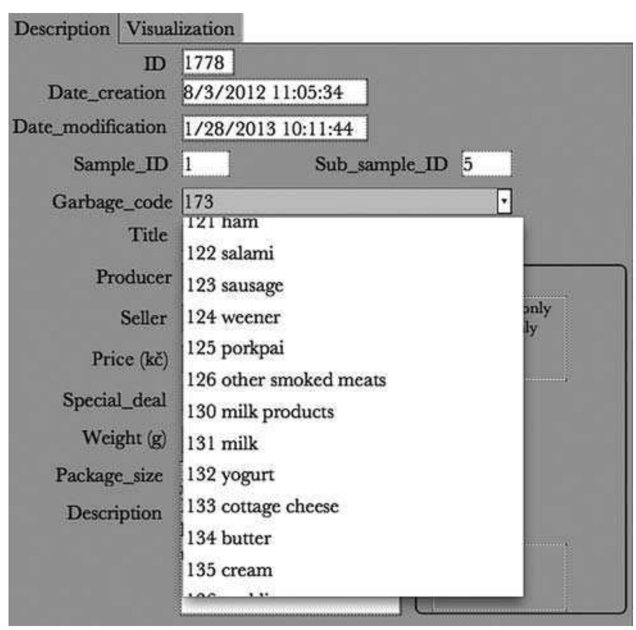

FIGURE 3. Screen shot of textual part of the form "garbage items" in the database.

nature of a sample or subsample such as ID, locality, weight, and notes. Since we took advantage of the relational tools of the database, we were able to insert fields that showed or calculated data from other tables. For example, our subsample layout includes a table containing information about IDs and basic characteristics of all items in the subsample. Also, two automatic fields calculated the number of items already recorded in the subsample and the total weight of these items.

Filemaker Go includes a chart tool. A researcher can prepare a layout that represents the data in a graphic form. We created charts to monitor the proportion of specific materials of garbage, wrapping types, producers, and sellers (*Figure 5*). We used this feature to keep track of the major trends in the data in the field.

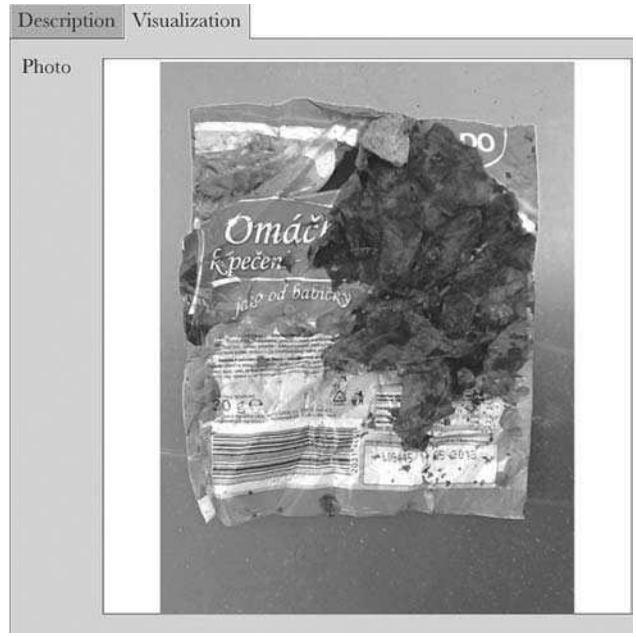

FIGURE 4. Screen shot of visual part of the form "garbage items" in the database. The picture was taken with the camera integrated in the tablet.

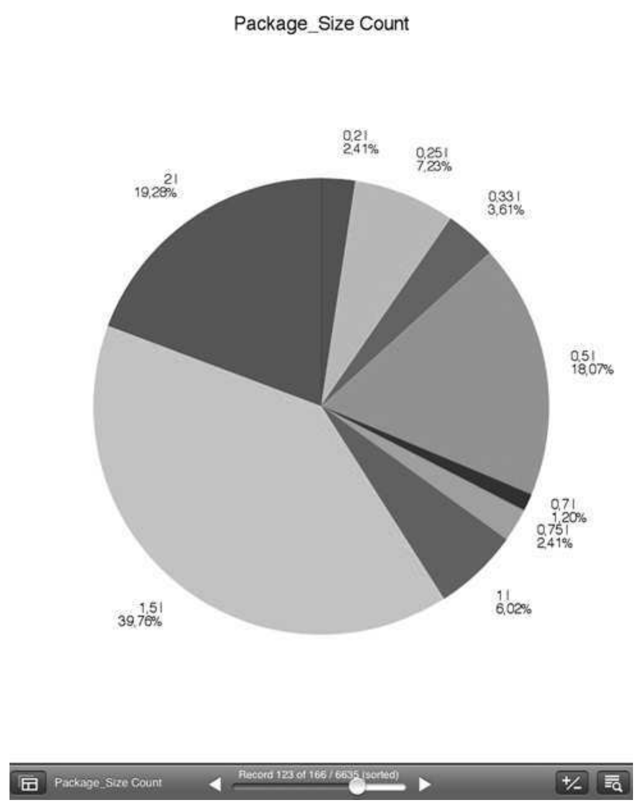

FIGURE 5. Screen shot of the chart report in the database.

PROS AND CONS OF IPAD AND FILEMAKER GO IN THE FIELD

The primary advantage of using iPad and Filemaker Go for field research is time efficiency. As multiple authors have argued (e.g., Fletcher *et al.* 2003, Gravlee 2002, Gravlee *et al.* 2006, Greene 2001), direct digitization of data in the field saves time. The most prominent benefit is that the researcher has the data organized and available at the end of the field research and a thorough analysis may follow immediately. This is a great advantage over the pen-and-paper approach where one has to invest several weeks or even months to digitize the paper forms. Moreover, the digitization of thousands of paper forms is prone to error. During our research we would have produced more than 3000 individual paper forms that would have had to be digitized. Nonetheless, we have to take into account time that was necessary for designing the database prior to the field research. The most difficult and time-consuming aspect was the construction of a logical structure for the database, field types, and especially 150 categories for garbage items. This phase took about a week. This preparation, however, would take place in the case of the paper forms as well, so the construction of the database and its adjustment for the iPad does not represent a substantial drawback. Moreover, the communication between the mobile version (FileMaker Go) and the desktop version (FileMaker Pro) of the software works well. It is easy to change the database in FileMaker Pro and upload the modified version of the file to the iPad.

The Filemaker environment – in agreement with other databases such as Microsoft Access or Base – provides other options on the level of individual fields, which make the research process efficient. We took advantage of auto-enter and timestamp functions. Every record received an automatic ID, the fields "sample" and "subsample" were automatically copied from the previous record and "date and time of entry" and "date and time of last modification" were timestamped. These features enabled us to skip several fields during data entry and save time. The advantage was not time efficiency only. The timestamp for the last modification proved to be a great tool for the identification of unintended deletion or overwriting, which can happen when researchers create and manipulate with thousands of records. When a strange record appeared in the database, it was frequently associated with a different time than the time of the original entry. Therefore, we had the opportunity to identify errors and correct them whenever possible.

Flexibility is another advantage of the system we used. Although FileMaker Go is not meant to be the standalone environment for designing a database, some database features can be modified in the field on the iPad. For example, the greatest conceptual challenge of our research was the development of garbage categories. We had to prepare a comprehensive classification system for all items that can appear in household waste. Although we were inspired by the Rathje and Murphy (2001: 21–22) classification system designed for North America, it was necessary to adjust it to the Central European context. During the first few days of the research, we faced the problem of garbage items that were difficult to classify. FileMaker Go enabled us to add new categories into the table "Garbage items", so we could resolve this issue directly in the field using the iPad without the necessity to modify the database in FileMaker Pro and then upload the modified version to the iPad. In case of multiple tablets in a single research project, it is necessary to make the modifications on each device.

The use of drop-down menus proved to be an excellent feature of FileMaker Go. Recording of 150 categories of garbage in the paper forms would require the use of a special overview paper form with all the categories and their numeric codes. The digital approach allowed us to scroll quickly in the drop-down menu and tap on the selected item. In addition, the FileMaker Go environment makes it possible to use multiple columns, which could be viewed in the menu, and the researcher could select the column that would be recorded in the database. In the case of garbage items, we were able to see both numeric codes and their textual descriptions on the iPad but only the numeric codes were recorded in the database for analytical purposes.

Any research that uses structured forms of data collection and includes common data between items can benefit from the capacity to search and duplicate individual records. In our garbological research, the redundancy of items found in the household waste was high. Items such as cigarette stubs, chewing gum, and milk tetra packs appeared frequently. Filemaker Go enabled us to use the "quick find" function to find the previous records using the key words and duplicate one of the previous records. After duplication, we modified information which differed from the original record. Indeed, FileMaker Go respected the rules for automatic fields, so when one duplicated a record, automatic fields such as "ID" or the "date and time of entry" were not copied from the original record but were created correctly for the duplicated record. We found this feature useful and it made our data collection much more efficient.

iPad and Filemaker Go make it possible to collect and integrate various forms of data in a single database. Such flexibility and robustness makes this research tool attractive because it offers a solution to the multiple requirements of field research in any discipline. In our research we integrated textual and visual data. Textual data were written or automatically created in the fields in the database. Visual data included photos that were taken with the iPad camera. The researcher just tapped on the "container" field and the iPad opened the application "camera" that took the photo and saved it directly to the database. This allowed us to take a photo of an individual garbage item and integrate it quickly and easily with the textual data. Originally, we prepared also a field for drawing sketches, because iPad and Filemaker Go support this function and we wanted to test it. Drawing worked well for rough sketches but this kind of information did not prove to be of much use for our research. Therefore, we dropped it after a few days of experimentation and replaced the field with another container field for photos. Also, for researchers who need to record audio data there is a possibility to use the container field in Filemaker Go for saving audio recordings.

The greatest advantage of our digital approach to data collection was continuous feedback and the cyclical nature of the research process. Given the fact that all data is available directly in the field, the researcher may check the consistency of the data, identify mistakes and missing data using searching and filtering functions in FileMaker Go. Quick reaction to challenges, which occurred during field research, enabled us to minimize inconsistencies and errors. Moreover, Filemaker Go makes it possible to track general patterns in the data via charts and fields based on calculations (*Figure 5*). For example, we were able to trace the total number of garbage items and total weight within subsamples to check quantitative differences among subsamples and evaluate the productivity of our work. Charts, which traced proportions of different kinds of waste, enabled us to think about basic data patterning while still in the field. Charts can show not only total proportions in the form of bar or pie graphs but they also support filtering. The researcher can filter, for example, beverage containers and visualize the proportion of different kinds of containers or trade marks. This function provides a new dimension to data collection facilitated by technologies. As Fischer (1994: 64–65) suggested, using computers in the field is not just about research efficiency but it also opens new possibilities to conceptualize new ideas and research directions. Tablets and databases enable the cyclical nature of the research process. The researcher can think about preliminary results in the field when he or she is still immersed in the research and interacting with the subject of the research. Consequently, preliminary interpretations appear in the field, researchers can discuss them and become more sensitive to critical aspects of the research or even modify their research strategy.

The reliability of the iPad and Filemaker Go in the field was excellent. The iPad is not designed for extreme outdoor use and cannot be compared to heavy duty handheld devices for field geographers and land surveyors, which fulfill the high standards for protection (e.g., international protection standard IP65 issued by the International Electrotechnical Commission). Yet the iPad worked well the entire field season in the challenging environment of the landfill despite the fact that we did not use any special protection cover or screen protector. Although we took advantage of an open tent, the environment was very dusty, windy, the temperature rose up to 35˚C, and we experienced storms during which the iPad was exposed to limited amount of moisture. The battery life was excellent. The iPad worked the entire day without trouble. Sometimes we even charged the iPad only once per two days. The software was stable and we never lost data due to "freezing" or software malfunction during the four weeks in the field. However, when a researcher takes hundreds of photos and the FileMaker file grows to several hundreds of megabytes, the iPad may get slower. The restart of the iPad resolves this problem.

FileMaker supports multiple users engaged in a single project. Researchers connected to a network can communicate with a server and data is synchronized among all devices. There are, however, two requirements that have to be fulfilled. First, researchers must purchase another piece of software, FileMaker Server, which supports the network solution. Second, iPads have to be connected to either Wi-Fi or 3G networks. There is a way around this for researchers who cannot fulfill these requirements. It is possible to create two or more versions of the same database file for each iPad and select a different starting value, for example 1, 10,000 and 20,000, for the serial auto-enter number "ID" to prevent duplication. The data from two database files can be merged directly in FileMaker Pro or exported and merged in a spreadsheet application such as Microsoft Excel for further analysis.

There are a few drawbacks concerning the use of the iPad and Filemaker Go in the field. The most crucial drawback is relevant for all projects that take advantage of direct digitization in the field. Digital data can be erased quickly by mistake. To overcome this issue, we backed up the data every night on a laptop computer, a flash disc, and once per week on an external hard drive. Also, one can create paper copies of data tables from FileMaker Pro via printing to reinforce the security of the data.

Our project worked with material things devoid of spatial context. Archaeologists, who record data about artefacts and ecofacts in the field, are exposed to more complicated situations because they need to record the position of things in space and draw plans and sections. Rugged laptops with drawing tablet capabilities have been used for these purposes with success (Searcy, Ure 2008). The system, which was used in our project, can be used to record these kinds of data but it has its limits. For example, it is possible to prepare simple drawings directly in FileMaker Go. The drawings, however, do not reach the quality and sense for detail necessary for archaeological plans and sections. It is possible to draw precisely using iPad and applications such as iDesign but the results are not integrated with the FileMaker database. The additional files can be linked to the database but this can happen only in FileMaker Pro on the desktop or laptop computers. For the recording of precise spatial data total stations are normally used in the field. To our knowledge, the data from the total station cannot be imported to the iPad in real-time in the field. Nevertheless, it is possible to type IDs from the total station measurements to FileMaker Go on the iPad and integrate data later in FileMaker Pro environment. It is not difficult to import, for example, four columns (i.e., ID, N, E, and Z coordinates) from an Excel file to FileMaker Pro. It just requires extra time and one has to double-check the data to avoid errors. It might be informative to note that iPad 3G can function as a GPS unit and latitude, longitude, and altitude can be recorded automatically in FileMaker Go. This feature can be very useful for field projects where researchers move in the landscape and record the location of objects of their interest.

For researchers working in remote settings there are a few critical features to consider. The iPad is not a standalone device. One needs a laptop computer or Bluetooth SD card station to transfer data from or onto the iPad. Also, charging the iPad is not always an easy task in the field. To charge the iPad with a solar charger requires several hours of uninterrupted energy flow. The iPad generation 3 is the most demanding in this respect.

Typing on the iPad is easy and works well for short texts such as notes and brief descriptions located inside the fields of the research forms (layouts). One cannot expect, however, that the iPad will provide the full-fledged environment for writing extended texts such as diaries or complex interviews. Although there is software that supports handwriting such as Audionote or Mental Note for iPad, we decided to combine the digital approach with the classic pencil-and-notebook approach. We used the old-fashioned approach for writing individual diaries of our research including various thoughts based on field experience, interaction with the waste, and humans who work in the garbage industry. Handwriting on paper has its own advantages that stem from different relationships between the body and cognitive processes as Ingold (2012) suggests. We believe that one should not be dogmatic about the application of technologies. Traditional handwriting on paper may be suitable for contexts where the researcher wants to produce longer texts and put an emphasis on creativity.

Duplication of records, which represents a great advantage for research efficiency, should be used with caution. The researcher should control the fields that get duplicated. During our research, we made mistakes in the container fields designed for photos. A few times, we duplicated the entire record including the photo but forgot to replace the original photo with a new one. We found it useful to check the database for duplicities during short breaks every few hours to overcome this problem.

CONCLUSIONS

Our experience with iPad powered by FileMaker Go database was excellent. The system was reliable and fulfilled our requirements for direct digitization of structured textual and visual data in the field. The process of data collection was efficient and all data were available immediately at the end of the field research for analytical purposes. The software was flexible and allowed us to modify some of the database features on the tablet computer in the field. The major advantage of contemporary tablet computers such as iPad is the ability to integrate multiple functions in one device. Researchers can type textual data, record audio data, take photos, videos, and integrate everything in a single system. The ability to examine preliminary trends in the data directly in the field yields a new dimension to thinking about the nature of the research process. Moreover, iPad represents a mainstream device, which is easy to obtain and does not require special training for potential users. The drawbacks of iPad and FileMaker Go appear especially in projects, which require special functionalities and working conditions. The proposed system is less efficient for the collection of precise spatial data, preparation of accurate drawings, and for projects in remote areas without good access to an electrical grid.

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