Sustainable Development as Successful Technology Transfer: Empowerment Through Teaching, Learning, and Using Digital Participatory Mapping Techniques in Mazvihwa, Zimbabwe

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Appendix C – Detailed Timeline of Analysis

1. Details of Analysis

During the workshops in March 2015, MV Eitzel took notes in a notebook during all daytime activities in Zimbabwe and journaled in the evening. At the end of the trip, she began discussing co-writing an evaluation of the mapping activities with Muonde mapping learners. When back in the US after the trip, she digitized the notebook notes and wrote additional observations of what happened each day and made a spreadsheet showing when each activity happened and who was involved. She used the same spreadsheet structure to plan and update activities for the 2016 trip (these spreadsheets form the foundation of table C1, below). In the intervening time between trips, she took notes on written reports from the GPS team which were send to her and on the tech support questions she received primarily from E Mhike Hove and A Changarara via WhatsApp. They also discussed the teaching and learning process over WhatsApp. A Ndlovu held a mapping workshop with the GPS team on their processes and learning experiences and sent notes to MV Eitzel, on which MV Eitzel also made notes and memos and from which she generated additional follow-up questions. In advance of the 2016 trip, she reviewed all these notes multiple times in order to generate preliminary ideas and themes for this paper.

In March 2016, A Ndlovu and MV Eitzel led two day-long workshops with all of the Muonde research team on assessing digital mapping in Mazvihwa: how we taught, learned, what worked and what didn't, what it was used for, and how it changed their relationships within and outside their community. We used a combination of role-playing, group discussion where each person was asked to share something, and brainstorming on flip charts. Collectively Muonde discussed and refined the main points of this paper, discussed who the audience of the paper should be, and who among them desired to be authors (arriving at the current authorship team). Through all these workshops, MV Eitzel continued to make notes and memos, informally coding them to revise the initial themes based on what the community was saying. Based on this workshop and the revised themes, A Ndlovu and MV Eitzel outlined the paper, and then next day the author team met for a day-long workshop to work on writing substantial parts of the first draft (mainly methods and results sections and contents of the appendices).

Both in Zimbabwe and afterwards in the US, MV Eitzel and J Solera digitized the portions of the paper written in the writing workshop. In preparing the first full draft of this paper, MV Eitzel again repeatedly reviewed all of the notes from both trips, WhatsApp transcripts, and workshop notes, annotating them as appropriate with new perspectives generated from additional years of working with the Muonde Trust members. MV Eitzel also wrote substantial portions of the methods, describing the

equipment as well as this writing and analysis process, and wrote substantial portions of the introduction and framing, including literature review, due to better access to academic literature. One challenge was ensuring that the paper was still representative of the community coauthors' ideas and culture, so Muonde author team members, as well as J Solera, gave extensive feedback on several full drafts of the paper and provided substantial input into the discussion section. The author team, including the Muonde authors, collectively felt that the final product represented our opinions and observations of the mapping processes, and MV Eitzel's editing added clarity without losing collective representation. After successive revisions and analysis by MV Eitzel and J Solera following peer review, some of the tone of the initial paper was lost in favor of framing and tone appropriate for a development engineering audience, as well as framing the paper for broader impact. However, the Muonde collaborators still felt it was their paper because the parts that they wanted to be included were still indeed present, even if much of that material was now found in the appendices.

We note that the writing and editing process was a significant portion of the analysis, and we thank our three anonymous peer reviewers for insightful comments that led to a major revision of the paper which included significant new synthesis of our results as well as many important clarifications of existing content and methods and a much stronger framing of the contribution our project makes to development engineering and participatory mapping. In that sense, the peer reviewers were an integral part of our analysis team and we are grateful for their comments.

2. *Controls for bias*

We took a number of different tactics to control for biases in our data and analysis. First, we do recognize that this is one example of one group. Muonde's community-based research strategies or attitude towards technological innovation might be unusual. We make an effort in the discussion section to think through how the approach could be scaled up and what might make that difficult in another context. Second, in addition to speculating on scaling up ourselves, we also give sufficient detail on our case to allow for "reader or user generalizability" (Merriam 2015): "leaving the extent to which a study's findings apply to other situations up to the people in those situations" (p 256). Therefore, following best practices for rigorous case study analysis, we have given a great deal of concrete detail on Muonde and our teaching approaches (Appendices A and B) so that other researchers, community-based and otherwise, can assess what might work in their situation.

Third, all the assessments in this paper have been made by individuals who were involved, invested in the success of the approaches, and excited by the results. There is no real way to correct for this bias; however, we do report on many concrete activities and achievements which reflect a diversity of mapping applications actually conducted by the team. We did also explicitly ask questions about challenges and limitations ("negative or discrepant case analysis," Merriam 2015) and make comments on aspects of the teaching which were difficult or methods that did not work (see Appendix B). Fourth, we rely on notes, memos, and heavily on memory recall to produce themes and when asking the community for feedback about teaching/learning techniques. Events were, however, somewhat recent: For the most part, activities had taken place in the last year when they were discussed at workshops, and workshops took place in the last year when the paper was initially written. If we had recordings or transcripts of workshops, we could have confirmed people's recall, and we also could have coded more quantitatively. Finally, the assessment only reflects a year or two of using mapping technology. A longer-term evaluation would demonstrate whether benefits would continue to accrue over time and

whether challenges could be surmounted (for example we already know that it has remained difficult with only one computer for more Muonde mapping team members to retain their map-making skills in QGIS). Regardless of these limitations, we believe our assessments are reasonably representative of reality and our approaches show promise for the use of digital mapping in developing countries.

Table C1 shows a high-level audit trail of the timing and details of the activities of this project, for the purpose of understanding the analysis and teaching methods in the context of how much time was spent, how many people were involved, and when.

Table C1: Detailed timeline of mapping activities: teaching, learning, use, and analysis. "Muonde GPS team" refers to the other initial mapping learners outside the author group. Not shown in table: in early mornings and late evenings during in-person visits, MV Eitzel would work with A Chirindira or A Changarara on reviewing that day's lesson or preparing for the next day's lesson.

Time	People	Activity/Location	Details
2015-Feb	MV Eitzel	Teaching (preparation) *US*	Set up software and hardware; prepare "How-To" sheets based on GPS units, software, and Acer computer, rough lesson plan; bring lamination materials to laminate after their feedback.
2015-Mar-14	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, Muonde GPS team	Teaching/ Learning *Zimbabwe*	Initial instruction on how to use the Acer computer, initial instruction on GPS units (points and tracks and waypoint averaging); MVE turn off gestural features on touchpad for ease of more tentative learners; use small markerboard to illustrate points and write down words; learn to use a thumb drive to back up and transfer data
2015-Mar-15	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, Muonde GPS team, villagers from Madzoke valley	Teaching/ Learning	Practice mapping points (borehole wells, trees) and tracks (crop field borders) with GPS units in Madzoke valley; based on A. Mawere's suggestion, initial Muonde learners instructed villagers from Madzoke and Murudhu on what they knew so far; farmers immediately got the idea of calculating field areas to know how much seed to buy
2015-Mar-16	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, Muonde GPS team	Teaching/ Learning *Zimbabwe*	Practice entering field notes into spreadsheet for connecting (joining) to locations from GPS unit; learning to download data from GPS units onto computer; opening maps in QGIS and zooming/panning around map; GPS team practices mapping in a nearby village (Madyakuseni), MVE nearby but not directly supervising
2015-Mar-17	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, Muonde GPS team	Teaching/ Learning *Zimbabwe*	Practice downloading data from Madyakuseni, adding to the map and changing colors, labeling points; further instruction on tracks and practicing walking around a neighbor's *bindu* (home field & yard) and discussing GPS measurement uncertainty, downloading tracks
2015-Mar-18	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, Muonde GPS team	Testing/ Practicing *Zimbabwe*	Half of the team: field trip to Great Zimbabwe (national monument and namesake of the country), mapping locations within the site; other half of the team: mapping points of interest in Mudhomori village
2015-Mar-22	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, Muonde	Testing/ Practicing *Zimbabwe*	GPS team members take turns individually demonstrating their ability to download points from the GPS units and adding them to maps in QGIS (with help from others as necessary)

	GPS team		
2015-Mar-23	A Changarara, S Gwatipedza, A Chirindira, Muonde GPS team	Practicing *Zimbabwe*	GPS team maps the communal grazing area in Mudhomori village while MV Eitzel is out of town in Bulawayo (MVE meanwhile learns how to create legends and scale bars in QGIS in order to teach the team when she gets back)
2015-Mar-24	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, Muonde GPS team	Teaching/ Learning *Zimbabwe*	Instruction on how to create printable maps (using QGIS' "Print Composer"); A Chirindira, A Changarara, and MV Eitzel make maps of each of the things mapped so far, in order to present to the whole Muonde Trust research group tomorrow
2015-Mar-25	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, Muonde GPS team, Muonde research team	Testing/ Presenting *Zimbabwe*	Each GPS team member presented one of the maps to the rest of the Muonde research team
2015-Mar-26	MV Eitzel, A Changarara	Analysis *Zimbabwe*	Discussing questions to answer about our process in a write-up of our teaching methods; MV Eitzel begins thinking about evaluation and authorship strategy for such a paper
2015-Apr-1-8	MV Eitzel, A Changarara, E Mhike Hove	Teaching/ Learning/ Practicing *US/Zimbabwe*	A Changarara teaches E Mhike Hove digital mapping techniques; MV Eitzel sends additional "How-To" sheets via email and does tech support over WhatsApp
2015-Apr-1–8	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, E Mhike Hove, Muonde GPS team	Analysis *US/Zimbabwe*	MV Eitzel digitizes notes from notebook, collects thoughts from evening journaling, writes other post-visit notes and memos on the teaching/learning; GPS team members, now including E Mhike Hove, write reflections/answer questions on mapping teaching and learning
2015-Apr-10 – Apr-19	MV Eitzel, J Solera, A Ndlovu	Analysis *US*	A Ndlovu visits the US, discusses the mapping team's successes and how to collect their feedback dynamically to complement their written reports
2015-Jul	A Ndlovu, A Changarara, S Gwatipedza, A Chirindira, E Mhike Hove, Muonde GPS team, other Muonde team members	Analysis *Zimbabwe*	Workshop on how the mapping went; A Ndlovu organized workshop and wrote up notes on GPS team members' responses to general questions and individualized questions based on their written reports
2015-Jul – 2016-Feb	GPS team	Practicing *Zimbabwe*	GPS team maps a wide variety of things locally and nationally (see Table 1), meets weekly to practice GPS skills; GPS team develops additional methods of teaching and metaphors; E Mhike Hove sends data to MV Eitzel
2016-Feb	MV Eitzel	Analysis, Teaching (Preparation) *US*	Reviewing notes, workshop notes, and WhatsApp messages, distilling preliminary themes to check with collaborators' impressions; discussing with colleagues how to do collective writing workshop
2016-Mar-5	MV Eitzel, A Changarara, S	Teaching/Learning *Zimbabwe*	MV Eitzel and A Changarara explain GPS satellites and present some global geography with a 1-m diameter

	Gwatipedza, A Chirindira, E Mhike Hove, J Solera, Muonde GPS team, other Muonde research members		transparent inflatable globe; refresher practical activity with GPS team members mentoring groups of other Muonde researchers; local GPS team members from Mudhomori download data and look at new high-resolution basemap imagery from DigitalGlobe
2016-Mar-6	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, E Mhike Hove, J Solera, Muonde GPS team, other Muonde research members	Teaching/Learning *Zimbabwe*	More refresher workshops with all of Muonde, reviewing waypoints and tracks, discussing lines and areas, looking at DigitalGlobe basemap imagery, practical exercise on making tracks to calculate lengths and areas, downloading data from GPS units
2016-Mar-7– 8	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, E Mhike Hove, J Solera, Muonde GPS team, other Muonde team	Practicing/ Presenting *Zimbabwe*	GPS team made maps of new data; each individual team member made their own map (in 2015 MV Eitzel made the maps and the team presented them to the group in Shona); presenting maps to all of Muonde (many in English indicating further confidence in the topic)
2016-Mar-9	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, E Mhike Hove, J Solera, Muonde GPS team	Teaching/Learning *Zimbabwe*	Advanced GPS topics: map projections, areas, uncertainty and calculating buffers; A Changarara, D Ndlovu, MV Eitzel calculate area of a garden to help assess the needs for a water pump for irrigation
2016-Mar-11 – 12	MV Eitzel, A Changarara, S Gwatipedza, A Chirindira, E Mhike Hove, J Solera, Muonde GPS team, other Muonde team	Analysis/ Evaluation *Zimbabwe*	All-Muonde workshop to assess teaching, learning, and using digital mapping technology: role-play activity, discussing who were teachers and learners, what worked and what didn't, what they used mapping for, how it changed their relationships, what the audience should be for the paper, what the main points should be, who should be authors; MV Eitzel and A Ndlovu outline paper
2016-Mar-13	Author group	Analysis *Zimbabwe*	Author group writing workshop: discussing outline, dividing into groups, writing sections of the paper (largely Results and some of Methods)
2017-Aug – Sept	MV Eitzel, entire author team	Analysis *US/Zimbabwe*	Reviewing notes and drafted sections, drafting full paper; all collectively reviewing methods, results, and discussion for validity and new ideas. Revising paper.
2018 Apr – May	MV Eitzel, J Solera, entire author team	Analysis *US/Zimbabwe*	Based on peer review comments, MV Eitzel & J Solera significantly revise, reframe, and synthesize the mapping processes and results; the whole team evaluates the resulting paper for validity and tone.

References

Merriam, S. B. (2015). Qualitative Research: A Guide to Design and Implementation. Wiley. Kindle Edition.