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Does Interactivity increase map user's reasoning? A study with environmental map users

André Luiz Alencar de Mendonça [a,*] Carina Coelho Lyra [a]

[a] *Universidade Federal do Amazonas. andremendonca@ufam.edu.br*
** Corresponding author*

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Abstract:

Concomitant to massive use of interactive maps the actual research agenda in cartography use and user's issues address the need of evaluating interactivity for specific map uses and users (ROTH et al. 2017). There is established scientific discussion concerning spatial tools and cartographic representations effects on learning and on increasing user's spatial capabilities and thematic knowledge which lead science of maps to develop methods for evaluating map user and use. This in order to better comprehend and quantify relationships around the extensive universe of map interactivity and contributing to advance a comprehensive theory in how to design interactions when dealing with spatial-temporal representations. As an area of growing interest for the last decade, this research field is being susceptible to technologic advances such as ubiquitous mapping, and map usage became a state-of-the-art study case for nearly all new interactive devices and systems.

There are several dimensions to comprehend interaction. This work presents a study case based on the concepts of map interface complexity model (Mendonça, Schmidt & Delazari, In Press) focusing on the interaction operators (Roth, 2013) and its effects on map reasoning (Olson, 1976; MacEachren and Ganter, 1990; Roth, 2012) and on cognitive workload (Hart & Staveland,1988) and SUS (System Usability Scale - Brooke, 1986), the later related to self-perception of usability, with both associated indicating better user experiences in the interaction with devices and interfaces (Longo and Dondio 2015; Borsci, Federici and Lauriola, 2009). Preliminary tests carried out with URUT usability remote evaluations showed more than 80% of usability issues can be assessed from workload and SUS forms (Mendonça, 2017)

The experience of the 1st author working with public sector and spatial analysis upon conservation of environment in the Amazonas state can be used to estimate that thousands of maps are produced every year to depict present and past situations of the subject, and these are being used by at least three main user groups: environmental professionals, which includes geographers, geologists, environment, forest, agronomic and fishing engineers, both in the public and private – including NGO - sectors ; education professionals and students, including high school, technical, graduation and post-graduation levels; society in general, considering the appeal of preserving natural ecosystem in one of the most diverse tropical forests in the world. These groups are used to define the study users sample.

Since this study is focused in map use and user's interaction, it carried out series of tests to measure and evaluate the role of interactivity in different levels of map tools interactions. Performance on better decision making and better understanding of environmental reality was stated and related to user interactions in order to answer if the variable level of interactivity can be related to better results on pointing out solutions to common maps ultimate goals: to support local and state policies on small scale issues like solid waste residuals disposal in small cities or analyze deforestation patterns together with forest fire focus against conservation units and the mosaic of protected areas. The study is part of a larger project which seeks to make better use of interactive technologies and to increase map use by different actors involved in the subject of monitoring Amazonas State environmental issues. This implies in identifying potential insights on environmental map use at local levels.

The research main goal was to answer if levels of interactivity will play direct role on increasing understanding upon environmental issues depicted in interactive maps. Secondary research questions include: 1) If environmental professionals consider using interactive mapping techniques when presenting results or studies related to the thematic, and if this can be perceived by means of their strategies of using their own maps or thematic interactive maps built for them. 2) What are current usability and acceptability gaps of proposed interactive map model considering the three evaluated user groups? 3) Will other continuum like the type of input device, user's personal characteristic plays a more decisive role in the user's performance? 4) Workload and Usability are related to task performance success when using interactive maps?

Therefore, a small set of maps was built in the context of Brazilian Amazon conservation and legal environmental cadastre (CAR), in order to discuss and present some issues for the region in last years. These true data map interface

and interactive tools were implemented using *Mapstudy* (SACK et al., 2016) an open source code software available at https://github.com/uwcart/mapstudy. The power of the framework to this research was to provide interaction tools, several mapping techniques (proportional symbol, choropleth, isarithmic, heat and dot maps), map services integration and performance evaluation by forms at the same interface, together with interaction tools (reexpress, resymbolyze, filter, query, underlay, overlay, sequence, reset, search, zoom, pan). Finally, *mapstudy* automatically log all interactions in a database in order to make possible to statistically analyze data.

Maps of this study were built depicting the southeast of Amazonas state, northern Brazil, along the Madeira River, region known by great anthropic pressure by *BR319* and *Transamazonica* roads. Environmental Thematic data was derived from 2013 to 2017 INPE's PRODES program (annual deforestation area measurement) and *BDqueimadas* database, which provide point data on heat focus and fire occurrences in the Amazon. Also, in a municipality level, data on inadequate disposal of solid waste was surveyed in urban areas of two small region towns for two months of 2017. Base maps included protected areas defined by Brazilian national conservation unit system (SNUC), municipal borders and urban neighbourhoods, and hydrography. Finally, some of preliminary Brazilian CAR data – rural properties declared land use – provided by State environmental and sustainable development Agency, were also used as a thematic overlay.

In order to ensure ecological validity and statistical empowerment, user sampling was based in two main aspects: First the quantitative analysis, which brought the need of evaluate interactions of a significant amount of users in the three user groups (~97 users, each). Type of device generated two groups of independent variable: screen size and type of input (touch and mouse input device). Also the three groups of users had the same types of maps and tools available and order of maps and randomized set of questions. Secondly there was a set of evaluation based on qualitative analysis of a group of users, notably environment and cartography professionals. This group (~10 users) were analysed by observation during usage and subject to a "think-aloud look like protocol" while interacting with the map and responding questionnaire about data. This specific protocol was used in order to understand actions and decisions taken during the procedure, and also to observe expected tool use. This set of users was analyzed by means of verbalized strategies and impressions about use, using a previously prepared form and based on recorded transcriptions.

Additionally, for all users, each map led to a set of questions concerning spatial relationships and environmental common issues in the Amazon e.g. ask map user to rank areas, considering priorities in surveillance actions; or quantifying possible fire focus in order to correlate to measured deforestation; or yet identify neighbourhoods and quantify occurrences of waste public collection issues. Previously discussed analysis was carried out by two specialists and results were taken as the best performance on these analyses from where each user input could be scored. Level of interactivity and types of interactions were quantified by means of number of interactions, which also led to a score (0 to 10 in both cases), meaning that 0 gathered no interactions and 10 the maximum number of different interactions considering all individual users results. For quantitative analysis, declared previous knowledge on the subject and demographic data (age, gender, experience with maps and with the subject, education) were also collected and used as independent variables in order to account for their possible influence on performance. Users were also encouraged to interact with the map interface by initial test instructions and had the support of hints on hovering tools in the interface.

Quantitative data is being analyzed using multivariate statistics, applying General Linear Model procedure to describe the impact of factors in dependent variables, including categorical factors (demographical data). Also correlation and linear regression are being used to describe how tightly a pair of numeric variables is associated, making possible to quantify correlation between the two measurement variables. Preliminary results show good acceptability of the map interface with low withdrawal during all tests. However, even with the use of hints, a considerable amount of users did not interact with map tools. This can be explained by low general experiences with cartographic theory and practical use with different mapping techniques. To the present, there is a tendency of correlation between workload, SUS and level of use (dimension of acceptability) of map tools, which means there is an indication of direct effect when using more interaction tools with appropriate levels of workload (average) and measured usability (maximum). Although, there is no evidence on better levels of understanding by means of performance, even in specialized or experienced users. *Mapstudy* is proven to be adequate framework to measure levels of interaction, considering a map interface built for specific tasks, but some cartographic techniques produce a considerably amount of time to be rendered. Logging interactions in database made also possibly to expand statistical analysis, since interaction logging generated detailed data on what type and how many times each of the tools were trigged, so it was possible to correlate each of interactions with performance, forms and qualitative results. The intention is to qualify interaction by means of multiple variable analysis and canonical correlations, in order to investigate which ones are more related to performance and usability and acceptability levels and why.

Qualitative survey data is currently being assessed, and expected results must help to explain employed strategies of thinking, mostly on why users choose some tools to interact despite of others, and how workload and SUS forms were used to express what happened during map usage. Finally, it is also expected to clarify if, in fact, the level of interaction is responsible for drawing better conclusions about spatial relationships.

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