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Development and evaluation of a specialized task taxonomy for spatial planning – A map literacy experiment with topographic maps

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A B S T R A C T

Topographic maps are among the most commonly used map types, however, their complex and information-rich designs depicting natural, human-made and cultural features make them difficult to read. Regardless of their complexity, spatial planners make extensive use of topographic maps in their work. On the other hand, various studies suggest that map literacy among the development planning professionals in South Africa is not very high. The widespread use of topographic maps combined with the low levels of map literacy presents challenges for effective development planning. In this paper we address some of these challenges by developing a specialized task taxonomy based on systematically assessed map literacy levels; and conducting an empirical experiment with topographic maps to evaluate our task taxonomy. In such empirical studies if non-realistic tasks are used, the results of map literacy tests may be skewed. Furthermore, experience and familiarity with the studied map type play a role in map literacy. There is thus a need to develop map literacy tests aimed at planners specifically. We developed a taxonomy of realistic map reading tasks typically executed during the planning process. The taxonomy defines six levels tasks of increasing difficulty and complexity, ranging from recognising symbols to extracting knowledge. We hypothesized that competence in the first four levels indicates functional map literacy. In this paper, we present results from an empirical experiment with 49 map literate participants solving a subset of tasks from the first four levels of the taxonomy with a topographic map. Our findings suggest that the proposed taxonomy is a good reference for evaluating topographic map literacy. Participants solved the tasks on all four levels as expected and we therefore conclude that the experiment based on the first four levels of the taxonomy successfully determined the functional map literacy of the participants. We plan to continue the study for the remaining levels, repeat the experiments with a group of map illiterate participants to confirm that the taxonomy can also be used to determine map illiteracy.

1. Introduction

Topographic maps do not only depict relief, but also natural, human-made and cultural features and provide an accurate and comprehensive graphic record of locations. Topographic maps are used extensively, for example, by soldiers for battle planning, by engineers when designing and planning roads, by geologists and surveyors for fieldwork planning and by spatial planners when developing plans for cities or regions (Innes, 1998). While popular, due to the graphically rich nature of topographic maps, they are considered difficult to read and understand (Chang et al., 1985). The abundance of symbols and colours used in topographic maps could be challenging, however, a comprehensive, well-designed legend can assist. According to Chang et al. (1985), the ability to form a 3D mental image of the terrain is considered to be the most challenging aspect when working with topographic maps. The map-reader needs to either interpret contour lines or deduce heights from spot heights.

Map reading is taught in school in many countries, specifically in primary and secondary education (Board, 1981). However, map reading is a complex task (Rayner, 1996; Board, 1981). In fact, Rayner (1996) reviewed various studies and concluded that *most* adults are map illiterate and unable to complete basic map use tasks. More recently, many more empirical studies highlighted the complexity of map reading tasks; even perceptual tasks that

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require no expertise, such as size of the symbols or colour discrimination, can hinder map reading severely (Clarke, 2003; Kent and Cheng, 2008; Brychtova and Çöltekin, 2014, 2015, 2016). Ooms et al. (2016) raised the question whether the increased accessibility of maps with the introduction of new technology and tools, such as Google Maps, has affected map literacy of individuals. They found that secondary education pupils (between the age of 11 and 18 years) were able to mostly successfully complete various map reading tasks at different levels of difficulty. This was especially true for older pupils and those currently enrolled for geography. However, the Ordnance Survey (2015) carried out a survey asking 2000 individuals which traditional skills they thought were in danger of dying out, and map reading was in the top spot. The reason provided was the increased reliance on technology, such as GPSs (Ordnance Survey, 2015; Bachmann, 2015). Bachmann (2015) suggests introducing activities into curricula that would alter a student's perception that GPSs and maps are perfect representations of the world. While it might be difficult for many people, map reading is necessary for many everyday tasks as well as professional use, e.g., topographic maps contain essential information for spatial planning and decision-making. Planners formulate plans for optimal land management and development in cities and wider regions. For this they rely on topographic maps (among various other data sources): from gathering information to communicating planned developments. Thus, map literacy is an essential skill for planning professionals. Surprisingly, however, Engel (2004) and Clarke (2007) found that map literacy levels among those involved in development planning in South Africa were simply inadequate. This mismatch naturally presents challenges for effective development planning and indicates a need for reforming the university curricula for educating planners and others who might conduct spatial analysis tasks related to planning.

Board and Taylor (1977) suggested that map reading experiments for adults rarely used 'realistic' map reading tasks, and that this might skew the results. It also appears that experience plays a major role in reading topographic maps, as experienced individuals are more efficient and effective in interpreting contours and visualization of terrain, among other spatial tasks (Kent and Cheng, 2008; Rinner and Ferber, 2005; Chang et al., 1985). A strong correlation has been reported between self-reported familiarity and experience with topographic maps and participants' performance with them in map reading tasks (Chang et al., 1985).

Map literacy tests designed specifically for planners simply do not appear to exist. Such tests could be used to evaluate map literacy and to initiate remedial actions, where necessary. In this article, we propose a map reading task taxonomy that is specifically relevant for the spatial planning domain. The map reading tasks in the taxonomy were derived from the tasks that are generally used in the planning process. Furthermore, we present results from a user experiment where map literate participants used a subset of the tasks in the proposed taxonomy, and we measured their map reading performance. We worked with map literate participants as a validation mechanism (i.e. we expected them to be successful with the tasks we prepared), and we chose a topographic map for the experiment, as topographic maps are commonly used by planners to gain a general overview of the environment, including terrain. The remainder of the paper is structured as follows: Section 2 presents the map reading task taxonomy; in Section 3 the study design is described; results are presented in Section 4; and in Section 5 the results are discussed and conclusions are provided.

2. Map reading task taxonomy for planning

Various researchers have identified and proposed map reading tasks for the evaluation of map literacy. For example, in 1990, Saku (1990) identified the following tasks involved in map reading: reading, analysing and interpreting geographic data. These tasks were extended by Keates (1996), as he justifiably discriminates between identifying and interpreting map symbols: the symbol has to be identified initially, only thereafter interpreted, and lastly, inferred if possible. This concept of tasks that build on each other from basic to advanced was also used by Clarke (2007) to define three map literacy skill levels for the evaluation of functional map literacy: read and understand a single symbol, do simple estimations (entry level); recognise symbol groups, analyse spatial patterns, more complex estimations (level 1); and understanding meaning and inferential reasoning of map phenomena (level 2). Clarke defined 18 map-use tasks and determined the map literacy level required for each task. Based on experimental results, Clarke argued that a person is 'functionally map literate' if the individual is proficient up to level 1. However, professionals working in the development planning environment should preferably be competent up to level 2 (Clarke, 2007; Rautenbach et al., 2014).

Developing an instrument to evaluate map literacy is not a new concept (Koç and Demìr, 2014), however to our knowledge, there is currently no instrument specifically designed for planning professionals. To develop our map reading task taxonomy for planners, we considered expert knowledge, peer-reviewed publications, and a number of additional resources, such as national reports and policy documents, and synthesized them (i.e., Board, 1978, 1981; Morrison, 1978; Clarke, 2003, 2007; Engel, 2004; Ordnance Survey, 2014, 1992; Department of Basic Education, 2011, 2012; Department of Education, 2008; Innes, 2005, 2003; Bolstad, 2012; Bayram, 2007; Wiegand, 2006; Department of the Army, 2001; Australian Government, 2005; Land Information New Zealand, 2009; Rayner, 1996; Saku, 1990; Keates, 1996). In the proposed taxonomy, we considered tasks for topographic maps, aerial photography and 2D maps (i.e., standard cartographic maps or thematic maps) as alternatives. However, in this study, we report results from an experiment that featured only a single topographic map, as the main idea was to test the taxonomy itself, and not make a map-type comparison.

The proposed taxonomy defines six levels of map reading tasks with increasing difficulty and complexity, ranging from recognising symbols to extracting knowledge (see Table 1). Level 1 to Level 4 (recognise symbology, orientate, locate, and measure or estimate) is considered to be the minimum for functional map literacy. These tasks (Level 1 to Level 4) form the basic building blocks for more advanced tasks. For example, during the first phases of planning (understanding the current environment), a planner/designer needs to extract knowledge from maps (e.g., spatial patterns or relationships between phenomena). For this, planners need to perform basic map reading tasks: recognise symbology on maps, orientate themselves on the map, locate features and estimate distances, etc. on the map.

The proposed taxonomy attempts to update previous map reading tasks that focussed on mainly paper maps. For example, Morrison (1978) listed unfolding as a map reading task. The map reading tasks identified by Board (1978) and Morrison (1978) were mainly a list of actions with little explanation that are applicable to various field and applications. Innes (2003) developed a system for school learners based on the South African Department of Educations (2011) geography syllabus. This system is based on the concept of a hierarchy of tasks that would ultimately contribute to a desired outcome. Innes' (2005, 2003) was basic as it is aimed at high school learners and very board. The abovementioned literature formed the starting point of the taxonomy that was developed by combining various resources to condense the information and verify that all possible tasks are included. Most taxonomies or map reading tasks list only focus on functional

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