Digital Age for Observations: The Use of GIS for Analysing Observations and Behaviour Mapping

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Abstract: The evaluation of the use of urban open spaces has always been a concern for the landscape researchers. Although they have use different techniques to identify this relationship, sometimes conventional research methods do not sufficient enough to capture the complexity. Behaviour mapping offers advantages to urban open space specialists to collect data, conduct cross-sectional, statistical analysis, and illustrate spatial distribution of behaviours on powerful maps and figures. This paper proposes to provide brief information on development and use of TOWEC (Tool for Observing Water Experiences of Children) and adaptation of this tool on to portable devices (D-TOWEC) for simultaneous data collection on the site. The TOWEC is innovative tool for evaluating landscape by observations and it is an attempt to evolve towards digital approach but D-TOWEC refers us to the future of observational research.

Keywords: Waterscape, children, behaviour mapping

1 Conceptual Background

Behaviour mapping is an observational method that has been used for more than 60 years, since *"Flanders system",* by researchers undertaking observations (BELL 2010). It is helpful for the researchers where non-participant observations are adapted and issues are more complicated than it can be identified by traditional approaches. Especially in urban open space research are more possibilities of variable that may affect the research. Therefore, new techniques were needed for understanding built environment. The pioneers of the technique were environmental physiologists and early examples were appeared in the late 60's and the beginning of 70's (BARKER 1968, ITTELSON et al. 1970). Especially, ITTELSON et al. 1970's book chapter was influential for many researchers seeking to understand the relationship between physical environment and human behaviour.

Behaviour mapping research has been influenced by two major concepts; concept of affordances (GIBSON 1979) and behaviour settings (BARKER 1968), which both were developed by pioneers of the method. Concept of affordances can be simply defined as human's ability to use physical environment in a different way than what it was originally designed and intended for. For instance handrails on the stairs might afford skateboarding on them, as well as being an aid for elderly people or tree in the park for shading might afford children's hide and seek games. Observing different uses of physical properties of built environment can enhance understanding of how the space is used. On the other hand, Barker's idea of behaviour setting is concentrate on patterns of behaviour in the physical environment, which can be specified by time and social character of the user such as age, gender and ethnicity. Barker's behaviour mapping concept underlie the foundations of modern outdoor behaviour mapping exercises but Gibson's concept of affordances help us to identify different uses specific physical environment.

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For more than 40 years researchers has been developing different techniques for observing human behaviour in the built environment and enhancing those concepts. Initial examples of behaviour mapping techniques were mainly concerned about counting behaviour in confined spaces such as classrooms. These early researches used pen and paper technique to record behaviour (MOORE 1986). Technical developments has helped the evolvement of behaviour mapping since 1980's. First attempts of digital recording was made by VAN ANDEL (1985) and in the following years many researchers were used time-lapsed photography, video recordings and radio frequency to identify human behaviour on built environment. However, the largest progress has been made since 2000's with the advancement of new technologies and ease of access (MCKENZIE et al. 2000, MALONE & TRANTER 2003, MCKENZIE 2006a, MARUŠIĆ 2011). The behaviour mapping has been taking new shape. Especially in the last few years adaptations of behaviour mapping to GIS environment started to increase because it is seen as straightforward and functional process that can be statistically analysed and used for creating unbiased results (MOORE & COSCO 2010). Moreover, using GIS base applications more complex data can be analysed to suit research needs performing cross-sectional and statistical analysis, as well as analysing spatial distribution. Furthermore, GIS interface help researchers to create well-organized maps that can be understood by many people, even by people who are from other disciplines and not familiar with the subject, which make dissemination of research easy and more successful.

Behaviour mapping method has always perceived as quantitative method. Early examples of the method counted the behaviour and some of the recently developed tools such as SOPARC (System for Observing Play and Recreation in Communities) and SOPLAY (System for Observing Play and Leisure Activity in Youth) (MCKENZIE et al. 2000, MCKENZIE 2006a) have also adapted very quantitative form of behaviour mapping. However, observation is qualitative base method, which is subjective to observer's eyes. Therefore, the use of field notes, photographs, description of body language of people observed, why and how the action has been taken by observed individuals can be explained in detail to strengthen the cases of reality behind patters of use occurring in the study site. The behaviour mapping has been used to study schoolyards (MALONE & TRANTER 2003), neighbourhoods (COSCOS et al. 2010), hospitals (BERNHARTD et al. 2004), housing settings for elderly people (MILKE et al. 2009) and many other public places.

One of the advantages of behavioural mapping studies is the direct observation of subjects in their characteristic environment. This allow researcher to study subjects with very limited or no influence, which allow us to enhance our understanding of what really happens in the built environment (MOORE & COSCO 2010). Another advantage of behaviour mapping is providing base for statistical analysis, perhaps regression analysis to investigate significance between physical environment, actions and physical activity levels of individuals (COSCO et al. 2010). For instance, observation of water play area specifically designed for children can enlighten the phenomenon that which one of the play equipment is useful for making different age groups of children physically more active.

2 The Brief History of TOWEC

The Tool for Observing Water Experiences of Children (TOWEC) was developed for research based on Sheffield, United Kingdom. The research aim was to explore what makes waterscapes in different urban open spaces attractive to children and what opportunities or constraints influence children's ability to experience these waterscapes. In this regard methodological triangulation was adopted as research methodology, which included three main methods: survey, interviews and observations. The study focused on three main sites that were selected according to criteria such as; different than each other in terms of character, type of water feature, location, design and children's water experiences. Three school were chosen to undertake children's and parental surveys according to non-probability purposive sampling technique, which is qualitative technique dependent on expertise of researcher on target population and objectives of study (WALTER 2010, DE VAUS 2002). Furthermore, interviews were done with parents, who took their children to waterscapes and also professionals who worked on design or management stages of the study sites were interviewed. The dataset developed by these methods were useful to understand what children, their parents and professionals think about children's experiences of waterscapes in the study sites. However, none of them has actually showed what really happened in there. In order to complete triangulation methodology, observations were also conducted.

Observation is useful research method to evaluate the landscapes; however, in this research systematic observation tool was needed for exploring spatial distribution of children in study sites and how those waterscapes used by children. On the other hand, none of the techniques and tools previously developed were not relevant for observing children's behaviour around water. Therefore, TOWEC was born. It was developed in four stages. First of all observation structure, which include study site boundaries and behaviour boundaries, observation sessions and session scheduling, and the number and duration of rounds of data collection, was set up. Administrative boundaries of study sites were set up as study site boundaries; however, observation boundaries was set to areas in and around the waterscapes, due to limited capability of sole researcher as observer. Trying to observe whole landscape in question and recording each different behaviour would not be relevant for achieving the research aim and would make research considerably difficult that might affect the validity of collected data.

The second stage of development of the tool was development of behaviour codes, which was the core of the TOWEC because children's behaviour around water had not been research in this sense and no tool had been available at time. This task required to develop new set of codes related with children's activities that would take place around waterscapes. Children's behaviours would be witnessed in the study sites were first hypothesised and later they were tested on pilot observations. Developed codes consisted of three major categories: Physical activity related codes, non-physical activity related codes and non-water related activities such as passing through the space.

The third stage of the TOWEC was developing age codes. Open space researchers has been used different age categorization according to their need in their research (MCKENZIE 2006b, FLOYED et al. 2011). However, age coding systems used other researchers were set for specific research purposes and would not be suitable for the new tool. It was decided to use much simpler but effective age categorization in TOWEC to underpin the change of children's interaction with water. Therefore, it was decided to use two age groups, young

children age between 0 and 9, and older children and adolescent age between 10 and 18, which was set according to previous knowledge about children's independent mobility. Many researchers from different backgrounds have investigated children's independent mobility and agreed that it increases rapidly at the age 10 (HILLMAN et al. 1990, HILLMAN, ADAMS et al. 1992, VEITCH et al. 2008, BROCKMAN et al. 2011, FOSTER et al. 2014). After age of 10 children become more independent and travel longer distances and go to the places just themselves or with friends. Furthermore, it is also easy to determine whether the child is younger or older than 10 years old.

The fourth stage of the development was determining the ethnicity codes that was adopted to TOWEC. These codes needed to be very simple to be used in open space, where identifying ethnicity of strangers would be hard task. In surveys and interviews United Kingdom Census 2001 Ethnicity Codes were used (OFFICE FOR NATIONAL STATISTICS 2001). Using the same ethnic coding system throughout the research was ideal; but coding system with more than 20 categories would not be suitable for TOWEC. In order the grantee the integrity of the research throughout all methods, it was decided to use codes in simplified titles. Moreover, detailed identification of ethnic backgrounds was not the concern in this research. Therefore, the 5 main subjects of "United Kingdom Census Survey 2001 Ethnicity Codes" were adapted to TOWEC such as; White, Black, Mixed, Asian, and Chinese and other. Identification of this ethnic backgrounds were much simpler and appropriate to detect, although it still included some subjectivity to researcher's eyes but this is integral part of the observations.

In order to analyse spatial distribution of children interacting with waterscapes in different circumstances, more variables were added to tool. For instance, date and day of the observation variables were added for comparing children's spatial distribution and behavioural patterns in the different days of the week. Time variable was added to make analysis of behaviour and spatial distribution in different time frames possible. In order to compare the effects of temperature on children's spatial distribution and behaviour area temperature was also added as variable. In this research wristwatch with thermometer function, which was tested and accurately showing outside temperature, was used. However, more accurate weather stations could have used, if the affect of temperate on human behaviour is main concern of behaviour mapping. Moreover, weather condition data input that consists of sunny, part-cloudy, cloudy, light-rain and heavy rain variables, was also added into the tool. For instance this made it possible to compare children's water interaction in a sunny day and cloudy day, when both outside temperature is over 20 degrees Celsius. Lastly, gender codes were created to compare different interaction patterns of males and females, as well as exploring spatial distribution of different gender behaviours.

A s mentioned before, the tool originally was created for hand record use. In order to collect data accurately and quickly the tool was consist of two elements. All variables in the behaviour-mapping tool were placed at the right hand site of the tool. Behaviour code symbols were also developed and places in this area. Scaled area map was placed on the left hand site of the tool (Figure 1). Using the tool data was collected with pen and pencil method, it was digitized using ArcGIS® by Esri. Geo-data bases for each different observation location were created. Observed locations of participants were recorded on maps in ArcGIS and attributes related with the specific participant were registered to attributes table.

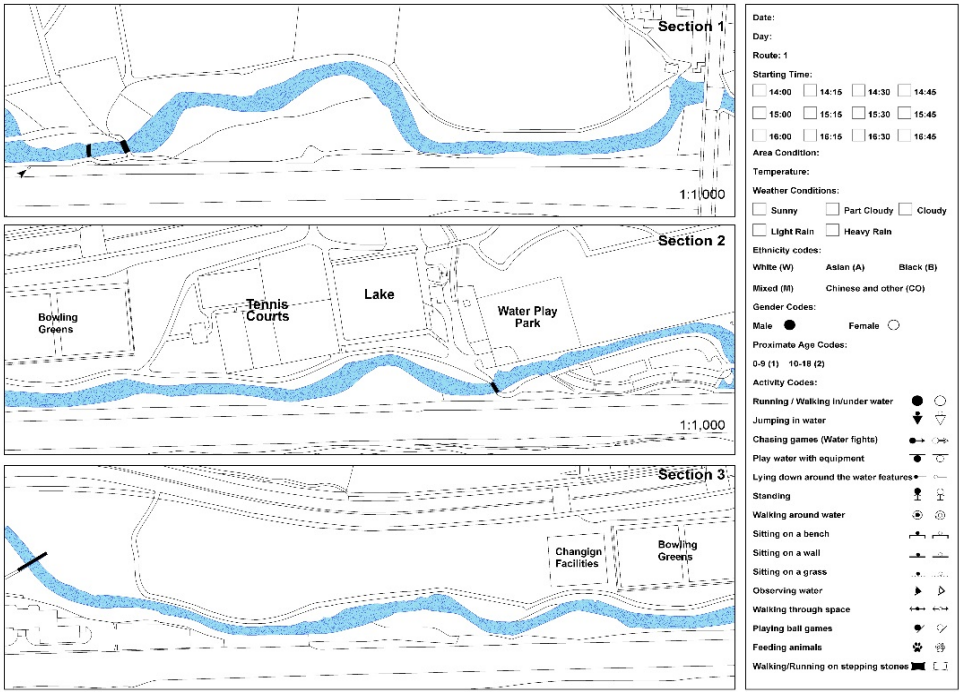

Fig. 1: Example of TOWEC on map

3 The Use of TOWEC

Using the TOWEC tool, behaviour patterns of children around waterscapes was observed for a year between summer 2012 and 2013. Due to fact that sole researcher working on this project, it was not feasible to observe 3 study sites on daily basis for a year. In order to use time efficiently, observations took place in school vacations and holidays when those sites would have been mostly used by children in theory. During school vacations and holidays 5217 children were observed in study sites. Every child was recorded in the location, after they have been observed for a while and their activities, ethnicity, gender, and age were noted in the coding system identified by TOWEC. Information about time, area condition, temperature, and weather condition was recorded in every round of observations, which was a 15 minutes interval.

Using this information many different aspect of children's interaction with waterscapes has been identified. Conducting this type of analysis in pen and paper technique would not be feasible because transferring hand recorded data from many different maps to one all around map by hand is impossible task. However, adopting it to digital approach and transferring hand recorded data to ArcGIS made all different kinds of analysis possible in the same environment and made it possible to visualize research findings. As was mentioned more than five thousand observations was recorded and all of these information can be represented on a map with the opportunities provided by adopting behaviour mapping into digital evaluation process.

For instance, in simple analysis the distribution of girls and boys interacting with water was identified and spatial distribution of this interaction was mapped (Figure 2). Girls were more interested in waterscapes compared to boys. Furthermore, ArcGIS also allowed conducting more complicated analysis with more than one variable such as spatial distribution of children's active and passive water interaction in different temperature. For instance, we are now able to determine all active and passive interaction and conduct cross analysis between activity type and Sheffield's 30 years mean average temperature 13 °C (MET OFFICE 2014, NIKOLOPOULO & LYKOUDIS 2006), in order to understand how weather effect children's interaction with waterspaces. As a result of this analysis, a behaviour map showing children's active and passive interaction below and above Sheffield's annual average temperature was created. Therefore, using ArcGIS software 4 different variables was easily cross-analysed (Figure 3). This analysis was conducted to explore whether children feel comfortable to undertake active interactions under Sheffield's annual average and explore spatial distribcution of those active and passive interaction on different temperatures. Emerging findings showed that not many children feel comfortable to interact with water actively under 13 °C but most of them prefer passive interaction. This analysis might have been made in more detail dividing outside temperature several degree ranges such as 0-5, 6-10, 11-15, 16-20 and 21 and above. Such a detail was not required in this research context but when it is reasonable to undertake that analysis, it can be easily conducted in GIS environment, which is the advantage of using GIS application for the analysis of behaviour mapping.

Furthermore, another layer of variable, the weather condition, was added to analysis mentioned above, in order to explore either the weather condition or the outside temperature is more influential on children's active interaction on waterspaces. This analysis also allowed us to understand how weather conditions such as sunny, part cloudy, cloudy, light-rain, and heavy-rain influence children's behaviour around water even though outside temperature is same. More precisely this analysis answered the question whether children are more interacted with waterscapes when outside temperature is 18 °C and sunny than 18 °C but cloudy.

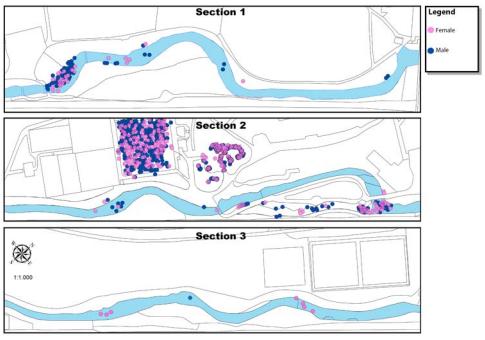

Fig. 2:
Distribution of different genders in Millhouses Park

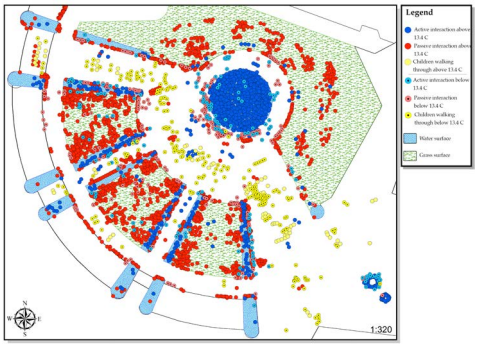

Fig. 3:
Children's active and passive interaction below and above Sheffield annual average in the Peace Garnes

Lastly, one more example of complex analysis will be discussed before moving to digital data collection tool D-TOWEC that was developed using the TOWEC tool as a base. For instance, in the city centre study site 9 different types of common behaviour was identified. In order to understand what kind of activities influenced by different age groups and explore spatial distribution of those activities, in GIS environment those activities cross-analysed by age groups. This type of analysis give researcher chance to gain better understanding of the phenomenon explored. In this research the analysis revealed how children's behaviour around water changes by age. Children's interactions with water move from active interaction towards passive interaction, as they get older.

As was mentioned above one of the main objectives of the observations to witness the truth and verify the participants written or spoken truth about what happens. In this circumstance TOWEC fulfilled its aim to show what really happens in the study sites and verified emerging findings from surveys and interviews. This digital approach to behaviour mapping for evaluating landscapes achieved much success. Moreover, statistical analysis can also conduct many of those variables available in the tool. However, in such qualitative study, it was not required to undertake deep statistical analysis to every variable. Numerous of different analysis that was not discussed in this paper was also conducted with data collected by TOWEC; however, the aim of this paper is provide methodological overview of the tool developed and how it contributes to development of the knowledge about digital approach to behaviour mapping. Research results about children's waterscapes study yet to be discussed in another article. Additionally, it provided many more variables witch were not required to analyse for fulfilling the objectives of this research but they might be analysed later on, in order to discover different characteristics of children's interaction with water.

4 The Preparation of D-TOWEC

The development and use of the TOWEC tool was discussed with a few examples above. As it was mentioned above all of those analysis were achieved by adopting digital approach in behaviour mapping and transferring data in to ArcGIS for analysis. However, at the time when the tool was developed smartphone and tablets were not powerful to run ArcGIS® or other GIS software on them and their applications were not commonly available. Although examples of digital data collection can be found on the literature more than 2 decades ago (VAN ANDEL 1985), when TOWEC was developed, adopting it into digital data collection format was not possible without having specific software developing knowledge. Only a few researchers managed to collect data digitally on the site but they used specifically developed software for their pocket PC (COSCO et al. 2010). Therefore, original TOWEC was developed for hand recording and later digitization of the data into ArcGIS.

However, today smartphones and tablets are more powerful than their predecessors available a few years ago. Moreover, software development companies developed GIS applications for those devices. Software developers even simplified the process of digital data collection for GIS applications, which might even allow researcher with limited software knowledge adopting their observation tool in to digital format. Therefore, it was required to take TOWEC a step further and make it fully digital data collection tool (D-TOWEC).

D-TOWEC tool is not an engineered software in its own rights but a tool that was developed using abilities of ArcGIS® software and Collector® application published by Esri,

which serves as a platform to view your maps created in GIS software and allow online or offline data input into those maps. First of all geo-databases with point feature classes created in ArcGIS®, as was the case with digitization of hand collected TOWEC data. Later on fields, which constitutes the structure of the information that is going to be collected in the field survey or study sites, were arranged. These are the key part of the tool created and include all variables in the original TOWEC tool. Variables in those fields set up as drop down menus for easy access and data input. After variable fields are arranged the symbols of those variables set. The only thing remains is publishing the mapping tool as online service, which than will make the map appear in the Collector® application. This simple system allows researchers with a degree of GIS knowledge prepare their own digital data collection tools. D-TOWEC is arranged as round maps, as is the case with original tool, which provided a platform for data collection in 15-minute rounds for smaller study sites and 15-minute sections for larger study sites. In this way the data, which will not change during 15-minute rounds or sections such as date, time interval of round, area condition, weather condition, and temperature are not need be recorded several time with every participant observed and recorded. Therefore, field worker only needs to make choices about participant's age, gender, ethnicity and activity they undertake during observed time limit. This makes the observations and recording process easier for field workers as they only need to record 4 variables for each participant before going back to observing others.

D-TOWEC tool has been piloted but has not been used in full time research yet. However, emerging findings from pilot studies suggest that D-TOWEC tool makes data collection easier for the research as it allows the use of portable devices such as tablets and smartphones to collect data on the site. Furthermore, it also makes time consuming process of recoding data manually by hand and digitizing data into GIS unnecessary. Moreover, collected data can be simultaneously synchronized through internet, which allow easy access to collected data on the computer for the analysis. Overall D-TOWEC is a better tool for collecting data about children's use of waterscapes.

5 Conclusion and Outlook

The purpose of this paper was to explore conceptual and theoretical background of behaviour mapping, discuss how TOWEC tool was developed and used in the research and discuss some of the possibilities the use of GIS applications allowed in behaviour mapping. Moreover, preparation of the D-TOWEC was also discusses in this paper to explore how this tool has been adopted to digital age. To date children's interaction with waterscapes hardly been researched and behaviour mapping as a tool was not used especially in digital format. Hence the significance of this paper is the exploration of how the state of art behaviour-mapping tool was developed and how it is adopted it into fully digital data collection suite, D-TOWEC.

TOWEC has proved to be useful tool for waterscapes. When the data transferred to ArcGIS, it helped to discover different relationships between many variables that would not be possible to conduct by hand. For instance, in a simple form tool allowed inspecting spatial distribution of different activities in waterscapes. Moreover, complex issues such as how children's behaviour changes in different weather conditions in relation with temperature and showed us either weather condition or temperature is more effective on children's

water interaction. Developing this understanding would not be possible with only simple observations or other methods (surveys and interviews) used in this study without the help of behaviour mapping tool. The results achieved with TOWEC tool possibly influence the planning and design of children's water spaces as it provides spatial distribution of children's water interaction.

The second objective of this paper was to discuss how tool was adopted to digital age and observations were carried into digital era. Although only piloted and not tested in fulltime research yet, the digital data recording tool, D-TOWEC, seems to be useful with its faster data input properties for field workers and it makes data ready for analysis as soon as it is recorded and synchronised. D-TOWEC offers a lot of time saving both on the field and in the office. When the development rate of the digital technologies are considered, even conducting analysis on the portable devices seems to be possible in a few years time. In this sense the tools like D-TOWEC seem to be the way to adopt observations and behaviour mapping into digital age.

Therefore, it seems to be more tools will be progressively adopted into digital era in the future. The knowledge created by development of both versions of TOWEC tool may have influence on the researchers working on children's waterscapes or researchers working on different fields of landscape to create their own behaviour-mapping tool, as development of TOWEC was influenced by other behaviour mapping tools.

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