Towards Smart City Education

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***Abstract*— Sustainability has been an important topic in UK schools for some time, most notably since the Sustainable School Strategy was proposed by the UK Department for Education (DFES) in 2006. However, as smart city technologies emerge and show real promise in contributing to a more sustainable future, it is becoming apparent that new skills for working with the big urban data sets that drive these innovations must be taught to upcoming generations to ensure that they can be active smart city citizens. Current practice within schools is to distribute teaching of different aspects of data skills across the curriculum. We ask the question how can data skills be taught using a more unified and practical approach, which facilitates application of skills in genuine, smart city contexts. We propose to use Urban Data Games to set a context for learning, and demonstrating, practical application of skills for handling large complex data sets. This paper focuses on an Appathon challenge, which will shortly be trialled in a Milton Keynes school, in which participants are tasked to design a novel App from real satellite data after first learning and applying data skills to data about home energy consumption.**

Keywords— smart city, urban data, urban innovation, sustainability, data literacy, citizen-engagement, game-based learning, inquiry, narrative, HDI.

I. Introduction

A report published by the United Nations in 2014 identified that currently 54% of the world's population live in urban areas and this is forecast to reach 66% by 2050, leading to increasing burden on urban resources and infrastructure [1, 2]. In recent years there is a growing interest in using "smart city" approaches to tackle urban sustainability issues [3], using data analysis to inform more intelligent city planning and use of resources. For example: a) use of fine-grained energy monitoring and prediction smart grid technologies to improve the efficiency of electricity distribution [4] b) taxi-sharing transport initiatives based on real-time vehicle location data [5] or c) data-driven planning of electric vehicle infrastructure [6].

Smart cities develop through both top-down and bottom-up innovative process [7]. In the top down view urban innovation is driven by the needs of local authorities or industry, to better plan city services and resource allocation or for more strategic advertising of goods or services. In the bottom-up view citizens identify, create, combine and use urban data sets to build ad-hoc solutions for local issues. Both types of innovation are important in the development of smart cities, especially since it is increasingly felt that the top-down view can ignore the 'on the ground' needs of the very citizens it is aiming to support [8]. In order for the bottom-up citizen approach to become a plausible reality citizens need to have the abilities and skills to make sense of the increasing amount of urban data and exploit urban data for addressing local issues. Today however, ordinary citizens rarely have these skills, which is a serious barrier for bottom-up innovation initiatives in future cities. As smart city technologies emerge and show real promise in contributing to a more sustainable future, it is clear that new skills for working with the big urban data sets that drive these innovations must be taught to upcoming generations to ensure that they can be active smart city citizens. In response we have started the 'Urban Data School initiative' to bring data skills to citizens and school children.

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II. Education for Urban Data Skills

A. Urban Data as Resource for Local Innovation

Urban data is increasingly becoming a resource for urban innovation. Cities around the world are setting up open data stores for making data and datasets available to the public. However, most urban data is not open and freely available but owned by commercial organisations such as utilities and transport operators. Urban data may be collected through sensors, smart meters, satellite imagery and mobile phones, but may also simply be derived from surveys and questionnaires. The data relates to a variety of topics, such as air and water pollution, energy and water consumption, crime, public and private transport, or car parking to give some examples. Some of the data is available in the form of live data streams which are real-time indicators of the state of the city system (such as traffic flow). Such data streams can generate huge data volumes that show huge variations across days, seasons and years, and – more often than not - are affected by data quality issues. Urban datasets can be combined and contextualised using background data such as demographic data or statistical data. This data complexity can be hard to support, therefore initiatives look at ways of providing access to multiple data sets from a single, searchable hub [9]. The work described in this paper is based on the MK:Smart data hub (http://www.mksmart.org/), which plans to manage and combine thousands of open and proprietary data sets related to the city of Milton Keynes with the goal to support both top-

down and bottom-up innovation that benefits the city of Milton Keynes and its citizens.

B. Smart Citizens

If citizens are to use and even innovate their own sustainable smart city solutions using big urban data, then they must have a good understanding of sustainability issues and possess the essential skills for using large complex datasets. The research questions we want to answer are how to teach data skills to 5-18 year olds, in an integrated way that supports the use of acquired skills beyond the classroom, particularly for urban innovation and sustainability. We also want to better understand what are the conceptual barriers to learning data skills at different ages and what approaches work to help overcome these barriers. This is a general research question within the emerging field of Human Data Interaction (HDI) [10] and one for which there is currently little evidence.

Sustainability has been a big topic in schools within the last decade, as evidenced through the sustainable schools initiative [11], which aimed to instil in the next generation knowledge of sustainability through experience of good practice within their own school environment, complemented by curriculum teaching on sustainability. Whilst this initiative has ended, there are still many enterprises available for schools, such as eco-schools [12], which provide resources, advice and awards for creating sustainable schools. Similarly, data skills are currently taught in school, but not in a holistic manner. Statistical analysis is taught in mathematics, the current Geography curriculum investigates how to use GIS and computing looks at modelling real world problems. Science subjects tend to focus on teaching data handling skills using learners' own personally collected, small, datasets [13, 14]. What does not currently occur is integrated teaching of data skills for large complex data sets within a real context of urban innovation and sustainability issues, i.e. 'smart city skills'. The next section outlines our practical approach to introduce data skills into schools.

III. URBAN DATA GAMES

We have developed an approach of Urban Data Games (UDG), in consultation with 5 Milton Keynes teachers from 3 different schools. The games are based on principles of narrative [15], inquiry [16] and game-based learning [17]. In a UDG, participants work in teams to address a given challenge using real urban data sets. The purpose of the challenge is to engage the interest of learners and to motivate them to get up to speed with the skills needed for participation. To support this, UDGs occur in two stages, the *learning stage* and the *challenge stage*. In the *learning stage*, students work cooperatively on data processing activities within a training dataset. The activities are designed to address common conceptual difficulties of working with big data sets and to teach transferrable data skills around selecting, analysing and visualising data from the training dataset to the data supplied in the next stage. In the *challenge stage*, teams work competitively. The challenge is time-based and provides a clear goal and rules for participation.

IV. UDG APPATHON CHALLENGE

One type of challenge that has been identified to be part of an Urban Data Game is an Appathon. An Appathon is essentially a type of Hackathon, where teams of programmers/designers co-create code to address a challenge, but with a specific focus on producing an App. Events typically take place over 1 or 2 days. In the lead up participants are given information to help them prepare, such as access to data extracts and documentation, API specifications, goals and judging criteria. Founders4schools have previously run successful Appathons with schoolchildren in the UK [18]. In this case, the focus has been on giving insight to young learners into skills needed for future jobs in technology.

We will conduct Appathons with schoolchildren, but with a focus on designing apps for urban innovation, which use and visualise one or more complex urban data sets. The Appathon is presented as a design challenge, with the key output being the visualisation of data and the urban innovation, rather than the technical development. This has the benefit of making the Appathon also suitable for younger or less technical students. We have two key data sets to be used as part of the UDG Appathon challenge. The training data set used in the *learning stage* is focused on smart meter energy data detailing home energy consumption of individual appliances across a period of time and also solar PV generation from these same homes. This data set has previously been used to explore the gap between home solar generation and energy use and the potential for shifting appliance use to times when the locally produced energy is used [19]. The Appathon data set used in the *challenge stage* is satellite data used to assess the presence of, or potential for, solar PV on houses in Milton Keynes. The examples we will use in this paper are based on real data, but for the purposes of publication have been completely anonymised.

A. Learning Stage

Prior to taking part in the Appathon, participants will be given access to a set of resources through which they can learn key data skills. Initially, participants will be introduced to the idea and rules of the Appathon, and given access to some examples of real Apps for urban innovation to set the context. Participants will also be introduced to real examples of urban innovation driven by big data. Next, participants will be provided with access to the training data, which is the home-energy data and the tutorial materials and tools for learning the key data skills through several activities. These will include 1) Create graphs of energy consumption and energy generation from solar PV for different seasons of the year (see Fig. 1) from an individual home and curate the graphs to tell a coherent story. Explore individual appliances, such as washing machine energy consumption and use patterns compared to the fridge. Explore patterns across multiple homes. Write stories to explain the differences. 2) Create data diaries over the course of a day or week to track activities that impact on energy consumption and identify where activities occur. Annotate activities where alternative data could be collected and used within urban innovation tasks.

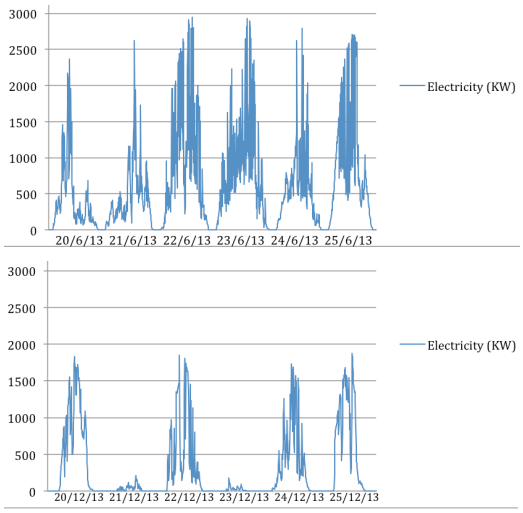

Fig. 1. Solar output comparison between 5 days in June (top) and 5 days in December (bottom)

3) Analyse the data diaries to identify common themes. Use this to identify/develop technology for urban innovation. Explore technologies for this, such as sensors to collect data and eco-visualisations for 'invisible' resources such as energy.
4) Create an energy map of Milton Keynes, and show how energy information might be visualised for individual homes.

B. Appathon Challenge Stage

The Appathon is competitive and has a time element. Whilst traditional hackathons are intense sessions occurring over a short period of time, we will in the first case run an Appathon over several classroom sessions to allow feedback and a better understanding of the problems. Students will be given access to the satellite data set and will be tasked with designing an App based on one concrete visualisation. An example of a visualisation can be seen in Fig. 2.

Fig. 2. Satellite data showing solar PV potential

The top image shows buildings that have existing solar panels and data to show what these existing panels might produce based on their size/pitch of the roof direction. The bottom picture shows buildings where the houses do not yet have solar PV but the data indicates their potential for creating it. Examples of Apps that could be created in this challenge include an App to identify the impact on energy consumption and the cost savings for specific estates in Milton Keynes, should they install solar PV on all houses in that local region.

V. Conclusions and Future Work

Urban Data Games aim to motivate and support learning of skills for working with large urban data sets using examples related to real life sustainability issues. They consist of a learning stage and a challenge stage. One type of Challenge is an Appathon challenge, this will be shortly trialled in schools in Milton Keynes. Other types of challenge are also being devised.

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