Creating an Open Data Application for Sustainability Education: Globe-Town

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1. Abstract

Globe-Town.org is an information visualisation using open data, designed to convey the connections between economics, society and environment in a globalising world. It informs about global challenges whilst being easy and enjoyable to use. It aims to motivate to act by showing how an intensifying network of linkages connects global sustainability issues to the home country of the user, and the topics that they care about. Globe-Town's central innovation in interaction design is how it combines visualisation of the properties of the individual country with a listing of the countries that are most strongly connected to it by a chosen type of relationship. This shows how ties of trade, migration, communication and culture increasingly connect countries, sharing the risks, responsibilities and opportunities of issues like climate change. Globe-Town takes a domain-specific storytelling approach to information visualisation, co-creating hypermedia narratives of sustainability and globalisation along with the user. Having sufficient open data availability is found to be highly valuable, as it prevents understanding of these expansive interdisciplinary problems being stymied by arbitrary limits of data access. Globe-Town has won second place in the *Linked Up Veni Open Education* competition and third place in the finals of the World Bank's *Apps for Climate* competition. This article describes the Globe-Town application in detail, along with the numerous online data resources that have enabled it, and the design and development process through which it was created.

Keywords

Sustainability; Sustainable Development; Sustainability Education; Environment; Climate Change; Economics; Trade; International Development; Complexity; Globalisation; Information Visualisation; Open Data; Linked Open Data; Web Science; Education; Human-Computer Interaction; Hypertext Narratives; Web Design.

2. Introduction

Globe-Town *http://www.globe-town.org* is a web application and an interactive information visualisation using open data designed to convey the complex linkages of sustainable development in a globalising world. In particular, it aims to inform people about environmental challenges, and to motivate them to act, by showing how the intensifying network of linkages connect global sustainability issues to the users home country and the topics that they care about, finding "narrative threads" of sustainability. The user can bridge the divide of scale between the global and local level, to help bring home what their discoveries mean to them personally.

Globe-Town uses World Bank open data [8], integrated with other data sources to provide a multi-faceted picture of all of sustainable development and climate change in particular, in all the countries of the world. Its design reflects the conventional organisation of sustainable development into the economy, society and the environment, visualizing many aspects of each, for each country (Figure 2, Figure 3). The software is designed to make the information easy and enjoyable to explore. Globe-Town shows how networks of relationships between countries (such as trade, aid, travel & migration) connect the user with distant places in an era of increasing globalisation. These links may transmit the risks of issues like climate change around the globe (e.g., the impact of the 2011 Thai floods on the Japanese economy [28]). They can also transmit the responsibilities for causing it (e.g., the embodied energy in exports from China [14]), and provide opportunities to act to mitigate and to adapt effectively (e.g., investing in renewable energy projects abroad). Globe-Town creates a metaphor between the familiar idea of neighbours in a town, and the relations between countries, represented them as a simple row of houses in a street. Globe-Town is a data visualisation based on PHP, MySQL, AJAX and the Google Charts API that brings together many intuitive design elements in order to make the information engaging.

Globe-Town was awarded second place in the *Linked Up Veni Open Education* competition at a ceremony in Geneva in 2013. It won third place in the finals of the World Bank's *Apps for Climate* competition [34].

3. Background

This project builds upon the new field of *ICT for sustainability* [13], and sits at the intersection of *web science* [5] and *sustainability science* [16]. It originates from the lead author's research into the use of web technologies to advance environmental sustainability and respond to climate change, and builds upon Tomlinson's analysis of the role of Information and Communication Technologies (ICTs) in sustainability education, in both formal and informal settings [30].

Interest in the use of open data for environmental sustainability [31, 36] is at an early stage, and has mainly focussed on promoting pro-environmental behaviours, good governance and more sustainable consumption through greater accountability [7, 17, 32]. Open data may promote efficient use of resources - such as in *smart cities* [4]. The role of open data in innovation and the transition to sustainability has received some attention [3, 25], as

has its role in science for sustainability [9]. There is a nascent international *open sustainability* community [20, 22]. However, we are aware of little research into using open data for sustainability communication and education.

4. Method and Concept Development

The methodology is one of research through design, originating from Human Computer Interaction (HCI) [37]. Zapico has adapted this into the following steps: *grounding, ideation, iteration* and *reflection* [35]. *Research through design* "uses design artifacts as outcomes to transform the world from its current state to a preferred state.", and its main characteristics are a focus on creating, an implicitly normative stance and the addressing of wicked problems [35].

The core concept was developed over several weeks through a *research through design* process, and also with reference to the *Getting Things Done* project planning process [1]. The first two steps provide *grounding*. The aim of the project was defined, the *purpose and principles*. This was to find a novel and engaging way of taking on aspects of climate change with a web application. Secondly, a clear *vision* was developed of what a successful outcome would be like. Success criteria included being intuitive and enjoyable to use, and the utilisation of open data.

Most effort was expended on the next two steps of *ideation* in order to identify a powerful central concept for the application. *Brainstorming* was used to suggest many potentially relevant topics, which were jotted down on small pieces of paper. These included varied aspects of sustainable development and climate change themselves, and the challenges they create such as planning, energy efficiency or education. The requirements of the *Apps for Climate* competition were noted down along with the form and subject matter of open data available. The lead author's research into the ways that web technologies can advance sustainability provided many ideas, as did consideration of the incentives for users to engage with the site.

The resulting concepts were *organised* and rearranged continually, in order to stimulate the imagination by creating novel combinations of concepts [11]. The core concept emerged from considering the country focus of the open data available, alongside the centrality of the interplay between sustainability and globalisation, in particular how the global nature of the atmosphere redistributes risks, and how the global economy challenges notions of responsibility for climate change due to the embodied energy of exported products. The design therefore focuses on both the nature of countries and the relationships between them, sharing the risks, responsibilities and opportunities of climate change in a globalising world.

Once the core concept was identified, *wireframes* of the interface were sketched and *iterated* through informal discussion with potential users. Once a promising user experience was designed, we returned to *brainstorming* and *organising* and finally *identification of next steps* in order to create a plan of action to build and *iterate* the software over a three-week period. The assembled team of six included software architecture and development skills, graphic and user experience design and project planning.

The developing interface design, combined with the focus on relationships led to the analogy with being neighbours in a street of houses. In turn, this led to choice of *Globe-Town* as a name, that expresses the interplay between the global and the local, and

references a place that has been heavily shaped by the forces of globalisation, in the East of London, UK. In particular, it is at the heart of the British-Bangladeshi community. The animated film created to introduce Globe-Town [33] draws heavily on the connections and contrasts between East London and Dhaka, Bangladesh through the lives of two characters. Linked for centuries by the globalising forces of colonisation, trade, migration and cultural exchange, they are also both low-lying and prone to flooding. However, whilst the UK has been able to invest in large-scale engineering to counteract the growing effects of climate change such as sea-level rise and increased precipitation, Bangladesh faces regular flooding and its population of 150 million face an uncertain future, with implications for its "neighbours" - including the UK. With Globe-Town, the user can explore such narratives of global change.

5. The User Experience

Globe-Town is a way of viewing information about the countries of the world and exploring how they are connected. It integrates these two perspectives of country and relationship, so the user can surf links from country-to-country around the world, like surfing the Web. Overall it follows the "Visual Information-Seeking Mantra: overview first, zoom and filter, then details on demand." [26]. Research into information visualisation has begun to move away from generic data analysis tools towards more overt storytelling with information [2, 19]. Globe-Town takes this more designed and domain-specific approach, actively narrating between user and data through the use of selected imagery to engage with ideas and emotions. The resulting stories are co-created by both designer and user, forming a hypermedia narrative [6].

5.1 Relationships Between Countries

When you select a country at the top of the main page, followed by a relationship between countries - such as trade - Globe-Town displays the countries that are most strongly connected to the selected country via that relationship (Figure 1). These 'neighbouring' countries are represented as houses along a street, with the size and proximity to the selected country's house indicating the strength of the relationship. Many of the relationships are of general interest, and several offer insights of particular relevance to climate change mitigation (air travel, trade in fossil fuels, electricity, wood, meat or concrete) or the sharing of climate change risk and ability to adapt (aid, overall trade, or investment flows). The first 25 partner countries are shown, both going to the selected country (e.g. imports) and coming from it (e.g. exports).

Figure 1 – A screenshot of a section of the Globe-Town.org homepage, showing trade relationships between China and its most prominent trading partners, represented metaphorically as a street of neighbouring houses. Importers from China are shown on the right in order of level of trade, with houses sized accordingly. Exporters to China are similarly shown on the left. Dropdowns allow the

type of relation to be changed (to e.g. migration or air travel), as well as the country and year.

sustainable development: economic development, social development, and environmental protection.

5.2 All about the Country in Question

Moving down the page, the user can discover much more about the selected country and the challenges and opportunities that it faces in a changing world (Figure 2). The grouping of these indicators, like life expectancy and economic growth, enables the user to explore the three interdependent components of sustainable development in that country: the environment, society and the economy (Figure 3). The careful labelling, sorting, colouring and imagery of the indicators are designed to maximise the clarity of where this country sits relative to the rest. Two Creative Commons licensed images were chosen for each indicator to communicate either higher or lower than the average for all countries, and where possible to create narratives that connect with the users personal experience and actions. For instance, where energy use per person was above the global countries average, this is represented with a large car. Where it was below the global average, it is represented by people cycling. For each indicator, countries were divided into six equal groups containing 16.66 percentiles each: *high/low, quite high/low* and *above/below average*. This categorisation works less well when data is very sparse for that year, or when many countries share the same value such as zero. All countries are counted equally regardless of very large differences in scale. The most extreme, and therefore potentially most interesting indicators for the selected country were ordered to the top of the column in order to be initially visible without scrolling.
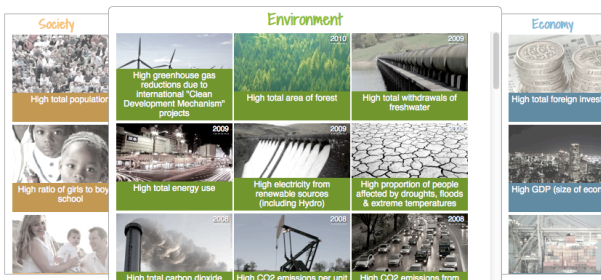

Figure 2 – Lower half of the Globe-Town homepage showing the detailed visualisation of the relative social, environmental and economic situation of the selected country, in this case China, presented in an engaging and readily understood visual style.

Figure 3 – A version of the conventional diagram of the three "interdependent and mutually reinforcing pillars" of

5.3 All about a Particular Indicator for a Country

Clicking on a country indicator opens up the indicator panel, where you can compare the chosen country to others for this particular indicator (e.g. a comparison of life expectancy to other countries). The indicator is compared to the countries with the highest and lowest values, and with the countries most closely connected to the selected country by the selected relationship (e.g. its most active trading partners). How the indicators vary around the world and how they have changed over time is conveyed via further simple data visualisations and a choropleth world map.
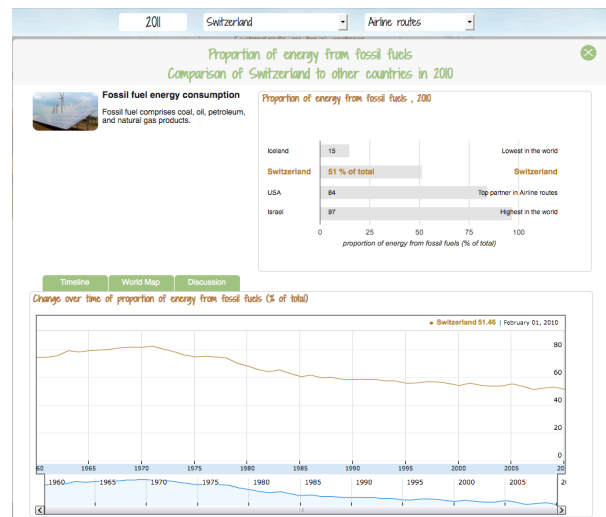

Figure 4 – The Indicator Panel, showing how the selected indicator (the proportion of energy use from fossil fuels) in Switzerland compares to other countries, and has reduced over time.
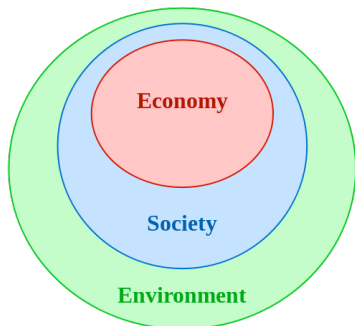
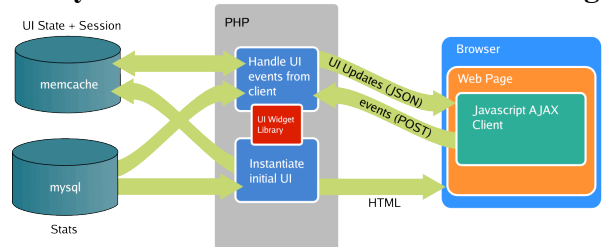## 6. System Architecture and Data Sourcing

Figure 5 – System Architecture of Globe-Town.

Globe-Town is a PHP application that uses the MySQL database server to store the data. A conventional RDBMS was chosen over semantic web technologies such as a triple store for a combination of performance and maintainability. The flexibility offered by other data storage approaches was not required given the very structured way in which Globe-Town makes use of the data.

The Globe-Town interface makes extensive use of Javascript and AJAX to provide a responsive web app that does not require frequent page reloads. This was particularly important given the

value placed on making Globe-Town easily accessible and in providing a good user experience. Charts were produced using the Google Charts API which enabled fast information visualisation. Performance limitations of Google Charts mean that future iterations would benefit from substituting more powerful visualisation tools such as D3.js.

6.1 Sourcing indicator data

Country indicators are the predominant data available on the World Bank's open data portal [29] i.e. a data point for each country allowing comparisons between them and across a very broad range of characteristics. The focus on countries provides a useful common data structure to compare many topics, and suits the global perspective of international bodies. Statecraft has neatly divided the physical geography of the planet into a limited set of relatively well-defined entities, albeit of highly contrasting sizes. This has enabled the World Bank to amass a rich compendium of datasets from many different organisations with the same structure, and enables Globe-Town's core interaction design. However, such simplification comes as a cost; much information is lost in averaging over a whole country. Similarly data is averaged over a whole year, so potentially large variations within these ranges of time and space can be lost, especially for large countries with great internal variations in physical or human geography, such as the USA or China.

Most of the datasets in Globe-Town were easily sourced from the World Bank indicator site. Not only does this provide a convenient technical standardisation, but also reassurance about data quality and clear metadata on provenance – which is reproduced for the user at the bottom of Globe-Town's indicator panel.

Nevertheless, in order to support the richness of climate change narratives intended for the application, it was necessary to fulfil several specific data requirements from other sources and even undertake considerable data processing to produce some of them. This was certainly helped by the general use of standard country codes such as _ISO 3166-1_ in most of the extra datasets found. However, not all datasets used standard codes - some simply provided names, which had to be carefully matched where possible using lookup tables of country name variations [24].

The World Bank Climate Change Knowledge Portal [8] provided data on predicted 2040-2060 temperature and precipitation levels obtained from the World Bank site, originating from the 2007 IPCC report [15]. This was deemed valuable to connect the user with the predictions of climate changes in store for their own country. Considerable averaging had to be employed in order to generate the singular indicators required for the application. The arithmetic mean was taken of the projected median increase in temperatures or precipitation across all models, for two scenarios (a2 & b1), across all months of the year and the two-decade period in order to give just one figure for comparing countries. The data is of course subject to the uncertainties, precautions, assumptions and scenario parameters pertaining to such predictive climate simulation.

Information on the vulnerability of countries to climate-related hazards and their readiness to adapt to the challenges posed by climate change and other global forces were sourced from the GAIN Index [12]. GAIN quantifies the countries readiness to adapt to climate change, as well as its vulnerability to it. The adaptation index is then calculated as the readiness score of a country minus its vulnerability score, normalised from 0 to 100.

Whilst it was preferred to use the data as provided with minimal processing, in order to develop the narratives around climate change mitigation, the relative potential of countries for the deployment of wind and solar energy were sought. For this, it was necessary to undertake a GIS analysis of data on wind speeds and insolation sourced from NASA via SWERA [27]. The accuracy of the result is limited; the data has a relatively low spatial resolution and does not include offshore areas..

One design challenge that could be better tackled in a future version of the application is to allow the user to switch between all _country total_ values to values _per person_, or indeed to _per unit area,_ or _per unit GDP_. At the moment these are mixed side-by-side, which may be confusing, especially when comparing large countries with small ones.

6.2 Sourcing relationship data

The World Bank's own Data Bank site provided a matrix of data about migration between countries. However, the most interesting country relationship data – trade – was sourced from _UN Comtrade_ [10]. In contrast to the other sources uses, this was not explicitly open data, with opaque terms of use, so permission had to be requested directly from the organisation. The effort involved illustrated the chilling effect of closed data on data reuse, and it is clear that this project would have been in no way possible without the broad provision of overtly open data.

Uploading overall trade data and trade in particular types of product of relevance to climate – such as the fossil fuel trade – was fairly straightforward. Data on the connections created between countries by modern air travel was of great value to both the climate change and globalisation narratives. This was sourced from the _Open Flights_ community of enthusiasts [23], and algorithms were applied to calculate the distance on the surface of a sphere between origin and destination. The displayed statistic shows the cumulative length of recorded airline routes between countries. This approach provides both a friendly way of visualising the intensity of traffic, and a reminder of the astronomical distances being traversed.

Data on international aid was sourced from the OECD [21], and thus includes only aid donated by OECD countries. However this is likely to make up the majority.

It is technically easy to extend Globe-Town to include other datasets for both indicators and relationships. It could be developed into a generic tool, or focus on a new specific domain. Data on international tourism could be readily included. One dataset of particular interest was investigated, but no good source of data could be found for it: the level of internet traffic between countries.

7. Future Work

7.1 User Testing

Globe-Town is in its first version. The priority for the project is systematic user testing in schools as a basis for iterative refinement and assessment of the design. Testing could assess: 1) how users' understanding of and 2) concern for sustainability issues develop, and ideally 3) whether it led to any change in behaviour; and even 4) resulting sustainability impact [18]; finally, 5) whether it is engaging and useful, by being both fun

and functional. For significant sustainability impact, it will need to appeal to those not previously interested in sustainability issues. Further conclusions could therefore be drawn into designing other information visualisations for sustainability education.

7.2 Features

Ideas for the development of the application include increasing the richness of available data and the ways of combining and interrogating the data. The system can be easily generalised with the inclusion of more indicators to increase the coverage of social and economic aspects in order to produce a tool of even greater general interest for education in subjects such as geography, economics and politics.

Globe-Town includes a central user experience innovation in the visualisation of networks, allowing the user to consider the nature of an individual item alongside the items most strongly connected to it by a particular relationship. The user can then surf from item to item and thus explore the relationships. This approach may be of value to exploring a broad range of different items linked in networks, such as companies in an economy, molecules in the metabolism or species in an ecosystem. It would be very simple to adapt it to these alternative domains.

Another development avenue for the existing sustainability-focussed system would be to enable users not just to learn, but to contribute to the content, communicate with each other and take action. This will allow them to go beyond exploring global links to creating new ones.

8. Conclusions

Globe-Town is a web application and an interactive information visualisation using open data that aims to inform people about sustainability, and to motivate them by opening up our world of connections to exploration, whilst bringing home what the things they discover might mean to them personally. By bringing more transparency to the rich network of our connections, it endeavours to introduce people to their distant next-door neighbours. It seeks to bridge the divide of scale between the global and local level, to connect the user to global sustainability issues by showing what they mean for her home country.

Globe-Town was created over a three-week period through a process of *research through design,* with four stages *grounding, ideation, iteration, reflection.* Its interaction design follows the "Visual Information-Seeking Mantra: overview first, zoom and filter, then details on demand." [26]. Research into information visualisation has begun to move away from generic data analysis tools towards more overt storytelling with information [2, 19]. Globe-Town takes this more designed and domain-specific approach, actively narrating between user and data through the use of selected imagery to engage with ideas and emotions. The resulting stories are co-created by both designer and user, forming hypermedia narratives [6].

Globe-Town's central innovation in interaction design is how it combines visualisation of the individual country's properties with a listing of the countries that are most strongly connected to it by a chosen type of relationship, such as trade. This generates narratives of globalisation: how ties of trade, migration, communication and culture increasingly connect countries. In a shrinking global village, the countries that you depend upon most - the countries with which you share the greatest risks, responsibilities and opportunities – are increasingly distant. The resulting visualisation allows the user to surf from country to country as they might surf from page to page on the Web. It also allows the user to explore the links that sustainable development makes between many different subjects, such as atmospheric science and economics. The interactivity of Globe-Town thus enables the user to explore the wicked problems of sustainable development: the synergies and trade-offs, agreements and discords between its different facets, the environment, society and the economy. The availability of sufficient open data is found to be highly valuable, as it prevents understanding of these expansive interdisciplinary problems being stymied by arbitrary limits of data access.

Globe-Town was created using many country indicator datasets sourced by the World Bank open data portal from diverse origins. In order to support the intended narratives of climate change and globalisation, it was necessary to also source several datasets elsewhere. These included datasets for different relationship such as trade, trade in particular products, air travel and international aid. It also included particular country indicators - some of which had to be calculated - such as the impacts of climate change on a country, or the potential for a particular renewable energy technology.

Beyond user testing and iterative refinement of the application, ideas for development include enabling users not just to learn, but to contribute to the content, communicate with each other and take action. They can then go beyond exploring their existing international links to forging new ones.

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