OPENSTREETMAP AS A TOOL FOR ENVIRONMENTAL NOISE AWARENESS EDUCATION — A PILOT PROJECT

Christopher Barlow, Juan Battaner-Moro, Margaret Jones,
Nick Whitelegg, and Paul Wright
Southampton Solent University
UK

Abstract

Environmental noise has been linked to a number of epidemiological indicators for stress, coronary disease, respiratory disease and other medical issues. Public understanding of the concept is poor, and public information sites are complex, not presenting users with context relevant information. The Open Source mapping system OpenStreetMap was used to develop an online public information resource for the city of Southampton. A key element of this was the development of an interactive map which allowed the user to explore the city from a noise perspective, and to investigate access to quiet spaces using a routing algorithm in the mapping system.

Introduction and Background

The relationship between the environment in which we live and quality of life has been assessed by environmental scientists and others for many years — issues such as air and water pollution, housing quality and social deprivation have been linked to factors including health problems and educational attainment, giving the overall picture known as Environmental Impact Assessment.

The issue of environmental noise as a 'pollutant' and its impact on health and welfare has become of increasing interest and importance in recent years across the majority of industrialised countries. Loud noise has for a long time been recognised as posing a risk to hearing, however lower levels of 'environmental noise', particularly that caused by road, rail and air traffic as well as heavy industry, has been linked to a number of non-auditory health effects (Babisch, 2005).

A key issue is that we cannot switch off our hearing system. Although humans may be able to ignore noise to a degree, hearing is a permanent process and noise can affect us at the subconscious level. Even low levels of noise that are considered 'safe' in terms of hearing can cause health effects such as increased stress hormone (Babisch, 2000), increased blood pressure (Haralabidis et al., 2008), and reduced cognitive performance (Bistrup et al., 2001) and have even been linked to increase in cardiovascular risk with increasing noise exposure (Babisch, 2000). The effect of noise on people has therefore become now a key topic in both environmental science and acoustics education. Despite this, environmental noise exposure is not currently used as an indicator for UK social deprivation statistics.

Not all sounds are categorised as noise. Natural sounds such as the rustling of leaves or waves crashing in a beach are considered positive and may increase well-being. In urban green spaces, positive soundscapes such as the sound of fountains or bird song are desirable features. The study of tranquil spaces is a relatively novel area of research and has been little studied in terms of health. Quietness and tranquillity have been found to contribute to satisfying lives for older people and exposure to tranquil areas of nature is thought to be stress reducing (Ohrstrom et al., 2006) and have positive effects on physical and mental well-being within the framework of a healthy lifestyle.

In 2002 the European Union (EU, 2002) developed the European Environmental Noise Directive (END). This requires large urban areas to model environmental noise, and to develop strategies to help protect people from the effects of noise. In particular there has been recent interest in the need for access to 'quiet' space to get away from noisy environments. The UK Department for Farming, Environment and Rural Affairs (DEFRA) defines quiet spaces as parkland 'green' spaces of at least 9 hectares in size and with an average noise level falling below a defined threshold. The concept of access to quiet moves away from a simplistic view of noise exposure, and 'tranquillity deprivation' could be considered more important to a location than average noise as it considers whether inhabitants are able to mitigate noise exposure using other resources.

The Aarhus Convention (UNECE, 1998) established the right of everyone to receive environmental information held by public authorities, which can include information on the state of the environment, on policies or measures taken, or on the state of human health and safety where this can be affected by the state of the environment. However, despite this, public awareness and education about noise exposure issues has traditionally been poor (WG-AEN, 2008). In particular the complex information provided by governments and organisations is difficult to understand as it uses measures and standards with which the general public is not familiar (WG-AEN, 2008). The understanding of key information by the general public is therefore limited, reducing their input into environmental decision making:

> For an effective public engagement, the public's understanding of environmental noise information is essential and it is very critical to present such information in such a way that it is easily understood and digested by the general public. (Law et al., 2006)

The question is how people can get information about noise exposure and in their neighbourhood linked to other relevant information. This includes access to quiet spaces, socio-economic indicators and health information that can be used to support decision making processes regarding lifestyle and health, and to support their input into environmental assessments in their residential location.

Web-based systems allow the presentation of complex information in a number of ways — in particular including interactive elements, and the layering of information to make complex data more accessible. While the use of online presentation of public health information is widespread, systems where the user can interact with material present the largest benefits to the user. Adults want learning linked to the real world (Schank, 1997) and to be based on their previous experience (Hartley, 2000). Graphical feedback and explanation also improves comprehension and retention of information (Rebetez & Bétrancourt, 2007).

This paper discusses the development of an online system that will be used to both educate environmental science students about environmental noise around the city of Southampton (UK) and to give the general public useful information and tools about environmental noise and tranquillity deprivation that will allow them to have a better understanding of noise in their local environment and how it might affect them, while meeting some of the strategic targets of the END.

Aims and Objectives

The main aim of the project was to develop an online resource for the city of Southampton which would allow users to understand both the key concepts of environmental noise and in particular give access to information regarding individual access to quiet space. This would also be linked to other social metrics. As most people are not able to easily move residential location, presenting practical information about access to quiet would give a practical application of the site which would be of use and interest to users.

A primary objective was set to develop a system which would link socio-economic data, residential addresses and spaces which have been identified as quiet spaces under the END modelling. The second objective was then to integrate this model into an educational website which would allow users to understand the ideas and then interact with the model.

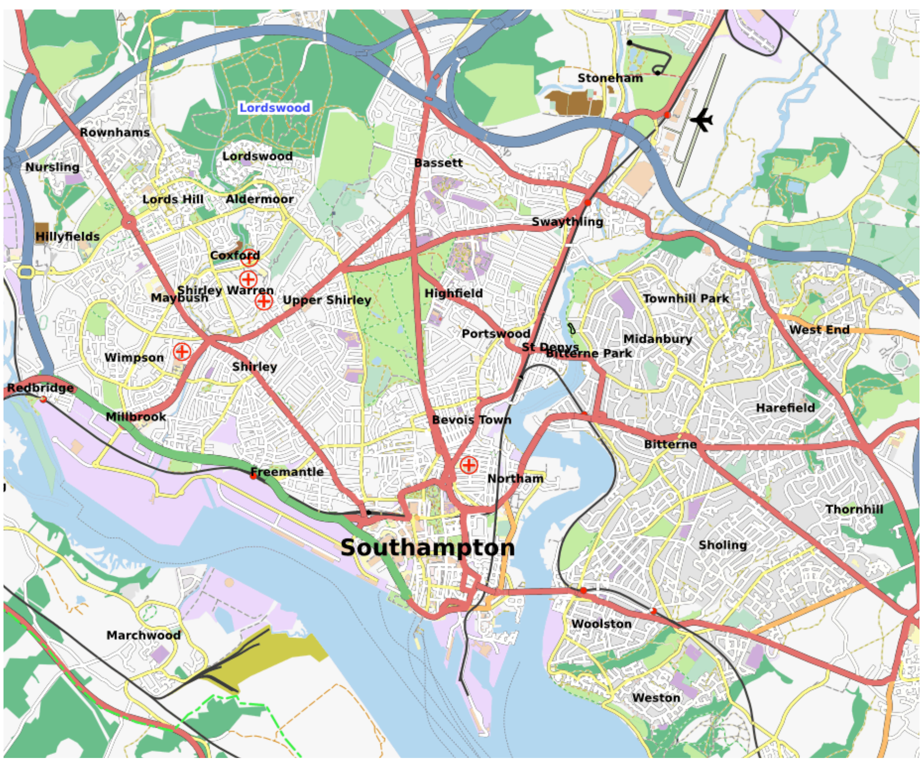
Stage 1

The first stage of the project was to analyse and map the key data that was needed to present to the public. This was split into three parts — social analysis, environmental noise analysis, and quiet space accessibility.

Social analysis. Southampton is a port city on the south coast of the UK (Figure 1), at the confluence of the river Test and the river Itchen, with the river Hamble joining just to the south of the city. It has a population of around 235,000. Southampton's parks make it the one of the greenest cities in Southern England. Close to the Old Town are seven formal parks which were originally common land in medieval times.

The largest of the parks (133 hectares) is Southampton Common, located relatively close to the city centre, and designated a Site of Special Scientific Interest. Five of the parks are over the 9 hectares stipulated by the END as the minimum size for a designated 'quiet space', and, of these, two are in locations which are above the minimum noise threshold due to proximity to the airport or major roads, while one is mainly taken up by sports pitches, leaving two parks (Southampton Common and Mayfield Park) which can be designated 'quiet spaces' according to the UK classification.

Figure 1: The City of Southampton

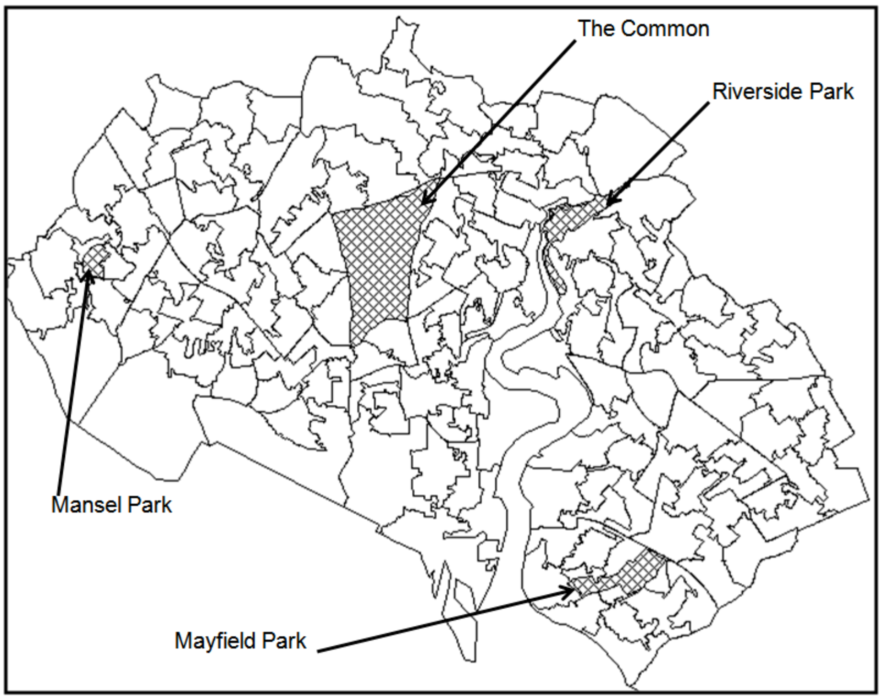


(source: OpenStreetMap.org)

In order to identify the most disadvantaged areas in England, deprivation indices are used so that resources can be appropriately targeted. To be able to measure deprivation at a smaller spatial scale, studies have been conducted at the 'Lower Super Output Area' (LSOA) level (Figure 2). These are a unit of geography used in the UK for statistical analysis by the UK Office for National Statistics. SOAs were created with the intention that they would not be subject to frequent boundary change. This makes SOAs more suitable to long-term analysis than other geographical units (such as political wards) because they are less likely to change over time.

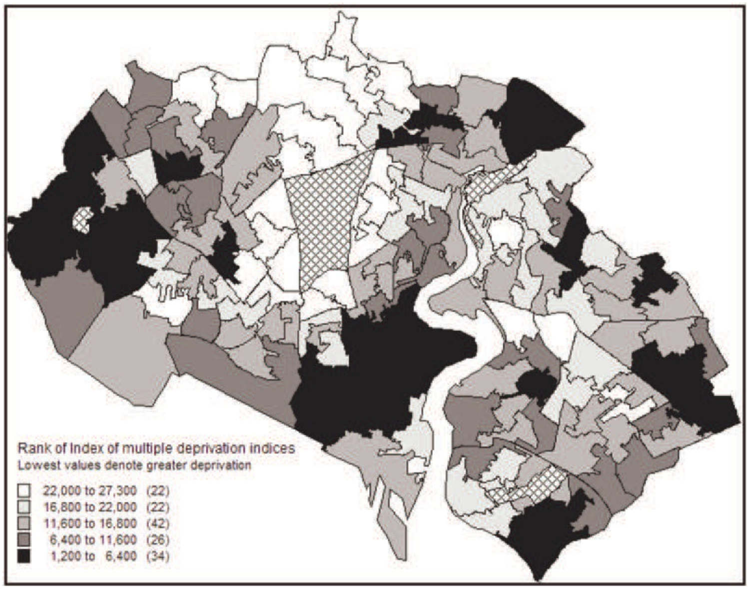
Lower SOAs have a minimum population of 1000 and mean population 1500. Each domain is assessed using a number of indicators, such as household overcrowding, criminal damage, houses without central heating, and so on. In total 38 indicators are used, but none of these indicators take into account environmental noise pollution.

Figure 2: LSOAs in Southampton, with Location of Major Parks



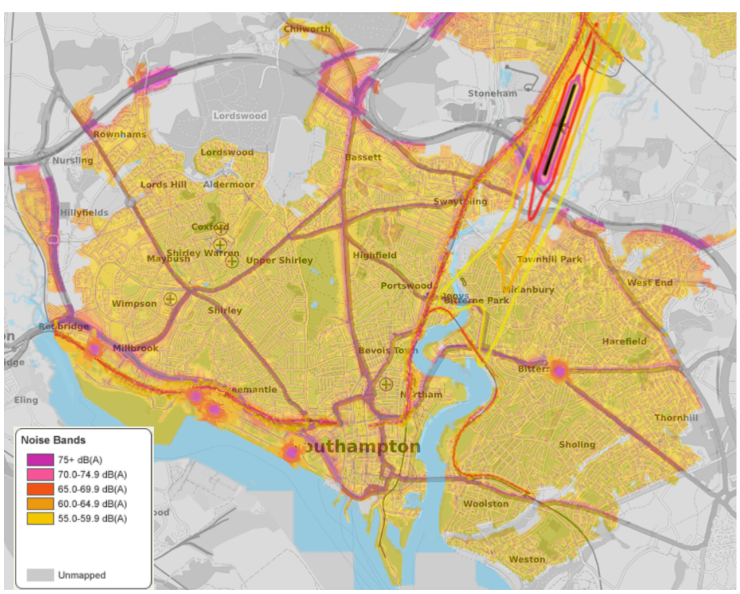
Social data for Southampton's LSOAs were derived from the Office for National Statistics (Noble et al., 2008) and this data was mapped using a Geographical Information System (GIS) against the LSOA boundaries. As a large number of social statistics are presented for LSOAs, it was decided to use the global 'Multiple Deprivation Index' (Figure 3) as the core social statistic as this summarizes the other indicators (Hampshire County Council, 2008). The latitudes and longitudes for all residential postcodes in Southampton (NSPD, 2010), were then mapped against LSOA boundaries to allow specific locations to be linked to its LSOA.

Figure 3: Multiple Deprivation Indicator at LSOA Level
(darker areas have greater deprivation)



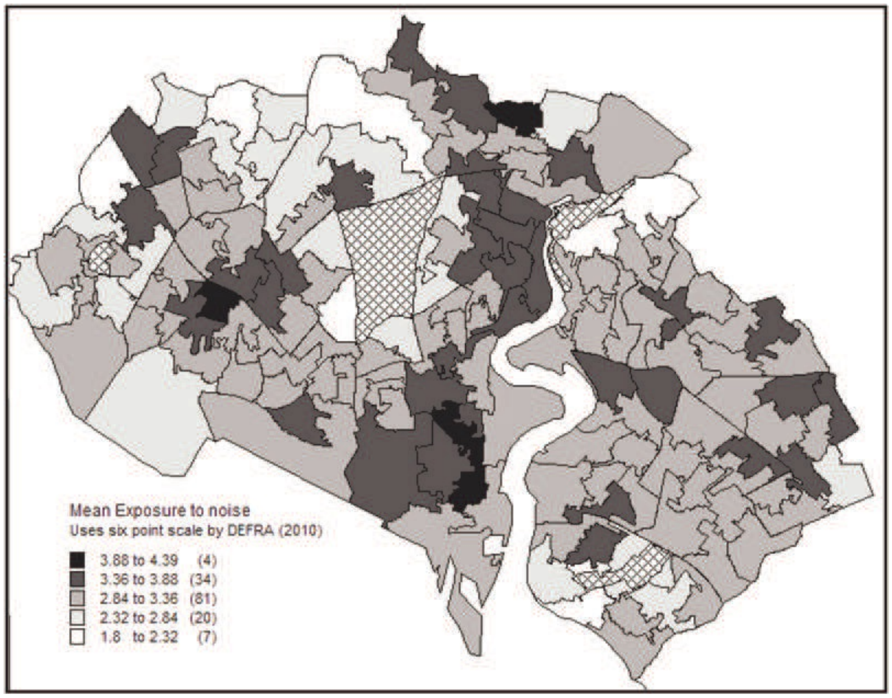
Environmental Noise Analysis. Under the requirements of the EEND, member states are required to model the noise exposure from road, rail, air, and industrial infrastructure for all large urban agglomerations with a population of more than 250,000 (Figure 4). In the UK this data is held by the Department for Environment, Food and Rural Affairs. While there are a number of issues with this dataset — such as lack of information relating to social behaviour — it is comprehensive and links directly to the information presented for other cities and countries. It was therefore decided to use this data rather than undertake new modelling.

Figure 4: Combined Noise Exposure (road, rail, air, industry)



The data for the END is mapped at a far higher resolution than the LSOA data, so the noise data was imported into a GIS layer and noise for each LSOA in Southampton was averaged (Figure 5).

Figure 5: Mean Exposure to Noise by LSOA
(darker areas are noisier)



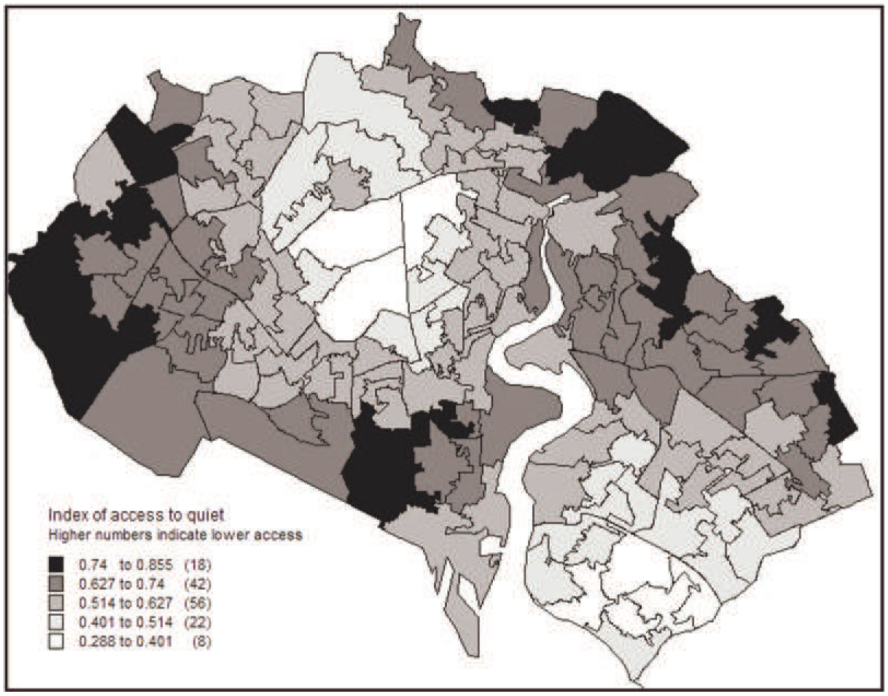
Quiet area access. In order to assess quiet area accessibility, the distance from a location to the nearest quiet space was calculated. This was initially undertaken manually, calculating the distance from the centroid of each LSOA to the edge of the nearest quiet area. This was then refined using the open source mapping environment OpenStreetMap. A script was written that would calculate the straight line distance from any postcode to the nearest quiet space, and this was averaged for each LSOA.

As city topology can mean that straight line distance is often not the most accurate distance measurement (for instance where rivers/rail lines intersect with a route) this was then further refined by developing a more advanced script based on a modified version of the Routino routing algorithm. This calculated distance to the nearest quiet space in the city via pedestrian route. The accessibility level was computed using the following formula (Battaner-Moro et al., 2010).

$$L_{acc} = 10\log\left(D / D_{\min}\right)$$

Where D is the mean distance to the nearest quiet area from the geographical centroid and Dmin is the shortest distance. The quiet area accessibility metric is calculated by taking the average of: Mean exposure to noise (L_{den}) + accessibility level for each LSOA (L_{acc}). This is shown in Figure 6.

Figure 6: Access to Quiet Areas Metric
(darker areas indicate poorer access)

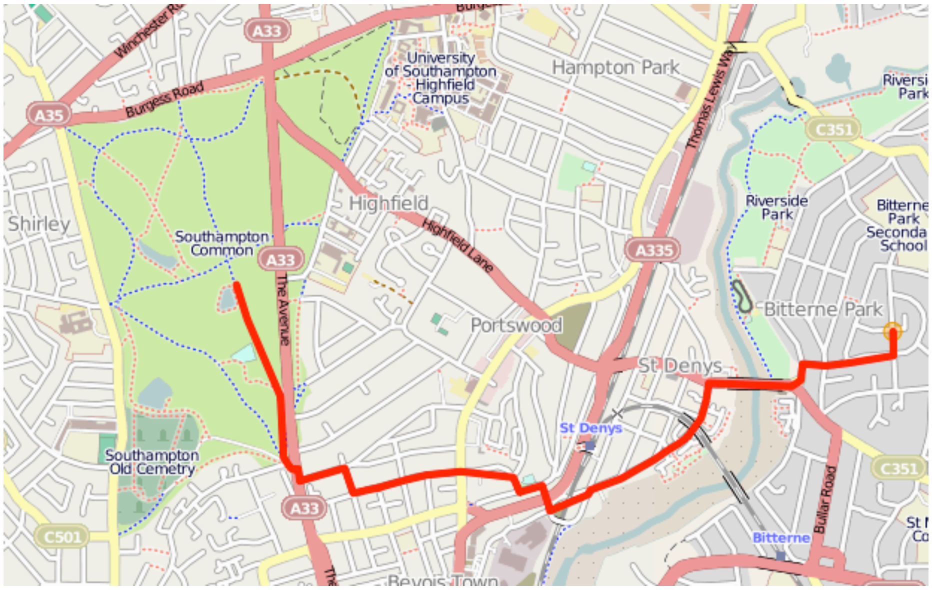


Stage 2: Interactive System

The next stage of development was to integrate this information into an interactive system to present to users. As the OpenStreetMap system had been used to develop the quiet area metrics, it was decided to continue to use this platform to present the data.

The routing algorithm was developed so that users could either enter a postcode or click on the map and the straight line route/distance to the nearest quiet space would be shown. This was then refined to show the pedestrian route and distance (in km) to the nearest park (Figure 7).

Figure 7: Mapping with Pedestrian Routing to Nearest Quiet Space



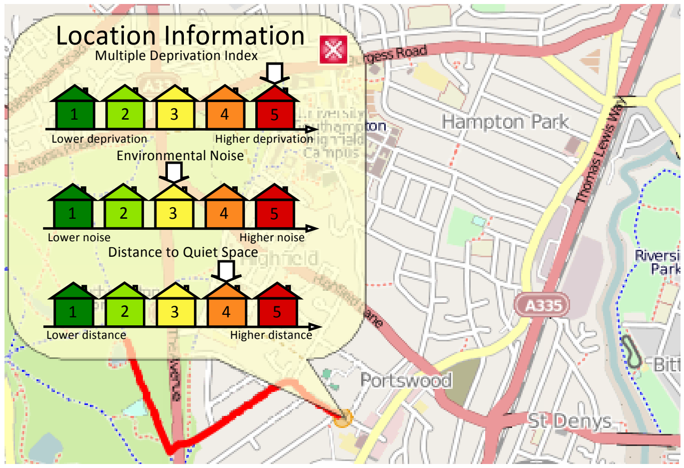
Each metric gives a value on a 5 point scale for each LSOA. This data was entered into a database which for each LSOA gave the latitude and longitude of the centroid position, an arbitrary reference number and the values 1-5 for each metric (Table 1).

Table 1: Excerpt from LSOA Database

Name	Areacalc	Centroidx	Centroidy	Multiple Dep	Environ noise	Quiet Access
029D	2.50505	-1.39811	50.8879	2	3	3
032D	1.48164	-1.36994	50.8792	2	2	2
031E	1.28775	-1.37762	50.8842	3	4	3
019C	2.02331	-1.45093	50.9103	3	3	5
009B	0.610815	-1.40266	50.9312	2	3	4
003B	0.998349	-1.36388	50.9408	1	2	2

A series of graphical representations were designed to clearly represent each of the three key indicators, and the database was linked to the interactive map so that when a position on the map was clicked on or a postcode entered, a callup window opened showing the indicators for that location, in addition to the route and distance to the nearest quiet space (Figure 8).

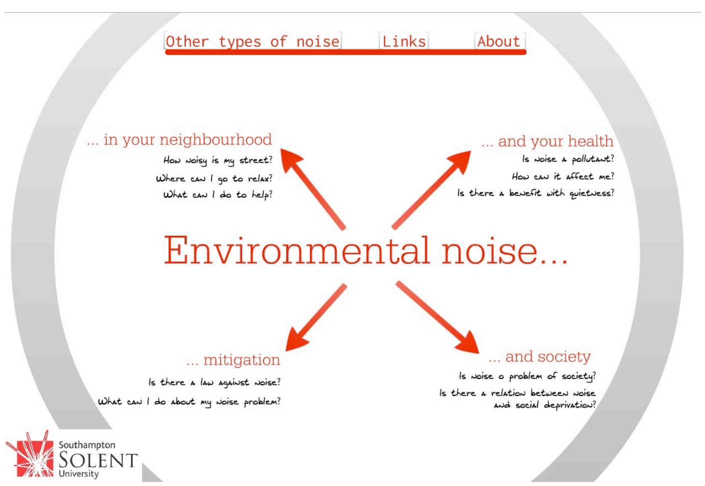
Figure 8: Mapping including Local Metrics and Route to Quiet Space



Stage 3: Website integration

The final stage for the project was to integrate the interactive mapping into a simple educational website which includes a range of information about environmental noise and its effects on people, along with explanations of the basics of environmental noise modeling (Figure 9). This site is designed to be simple, visually appealing and based around the concept of people 'exploring' the city, and using supporting facts and information to aid their understanding, moving away from the dry, 'fact-led' approach of many public information sites.

Figure 9: Front End for the Pilot Website



Conclusion

The majority of public information sites are didactic in nature, presenting complex information with minimal interactivity. This site aims to use the discovery learning capability of the map combined with supporting information to help people explore the concepts of noise and access to quiet around their city. The use of OpenStreetMap has allowed the presentation of complex, location specific information in an easy to understand, relevant manner.

The site blends general ‘knowledge based’ information to explain concepts with ‘context specific’ information for each location. This allows users to explore the city online, relating the information to their own knowledge of the area. This is based on a constructivist concept, whereby the learner draws on their own experience, and explores a problem with questioning and experimentation to discover new relationships and facts (Bruner, 1967), which may increase content relevance and learner engagement (Rieber et al., 2004).

This project is designed to help educate both students and the public about their local environment and give interactive, practical information which they will find relevant and useful. The project site is in the process of being trialled as a pilot with undergraduate environmental science students before open release to the general public.

References

Battaner-Moro, J, Barlow, C. & Wright, P. (2010, April). Social deprivation and accessibility to quiet areas in Southampton. *Proceedings of Noise in the Built Environment.* Ghent, Belgium.

Babisch, W. (2000). Traffic noise and cardiovascular disease: Epidemiological review and synthesis. *Noise and Health, 2*(8), 9–32.

Babisch, W. (2005). Guest editorial: Noise and health. *Environmental Health Perspectives, 113*, A14–A15.

Bistrup, M. L., Hygge, S., Keiding, L., & Passchier-Vermeer, W. (2001). *Health effects of noise on children and perception of risk of noise.* Copenhagen: National Institute of Public Health.

Bruner, J. S. (1967). *On knowing: Essays for the left hand.* Cambridge, MA: Harvard University Press.

EU. (2002). *Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise — Declaration by the Commission in the Conciliation Committee on the Directive relating to the assessment and management of environmental noise.*

Haralabidis, A. S., Dimokopoulou, K., Vigna-Taglianti, F., Giampoto, M., Borgini, A., Dudley, M., et al. (2008). Acute effects of night-time noise exposure on blood pressure in populations living near airports. *European Heart Journal, 29*(5), 658–664.

Hartley, D. E. (2000). *On-demand learning: Training in the New Millennium.* Amherst, MA: HRD Press.

Law, C. W., Lee, C. K., & Tai, M. K. (2006). *Visualization of complex noise environment by virtual reality technologies.* Science in the Public Service, Government of Hong Kong. Retrieved February 8, 2011, from http://www.science.gov.hk/paper/EPD_CWLaw.pdf

Noble, M., McLennan, D., Wilkinson, K., Whitworth, A., & Barnes, H. (2008). *The English Indices of Deprivation 2007*. HMSO Department for Communities and Local Government.

Ohrstrom, E. et al. (2006). Effects of road traffic noise and benefit of access to quietness. *Journal of Sound & Vibration, 295,* 40–59.

Passchier-Vermeer, W. (2000). *Noise and health of children*. TNO report PG/VGZ/2000.042. Leiden: Netherlands Organization for Applied Scientific Research.

Rebetez, C., & Bétrancourt, M. (2007). Video game research in cognitive and educational sciences. *Cognition, Brain and Behaviour*, *11*(1), 131–142.

Rieber, L. P., Tzeng, S., & Tribble, K. (2004). Discovery learning, representation, and explanation within a computer-based simulation: Finding the right mix. *Learning and Instruction, 14*(3), 307–323.

Schank, R. (1997). *Virtual learning: A revolutionary approach to building a highly skilled workforce.* New York: McGraw-Hill.

UNECE. (1998). *Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters*. United Nations Economic Commission for Europe. Retrieved February 11, 2011, from http://ec.europa.eu/environment/aarhus/index.htm.

WG-AEN. (2008). *Presenting noise mapping information to the public*. European Environment Agency Working Group on the Assessment of Exposure to Noise. European Commission.