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ASSESSING AN OPEN SPATIAL DATA INFRASTRUCTURE FROM A USER PARTICIPATION PERSPECTIVE: A QUALITATIVE EXPLORATORY RESEARCH WITH OPENSTREETMAP

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1. Introduction to Open Spatial Data Infrastructures

1.1. Spatial Data Infrastructure developments

Governments have invested in establishing Spatial Data Infrastructures (SDIs) to facilitate sharing spatial data between government organisations. An SDI is a framework of policies, access networks, data, standards and individuals that promote, coordinate and facilitate the dissemination and use of open spatial data for users in the spatial data community (Rajabifard and Williamson 2002). Initially, production and distribution of spatial data was limited to national mapping authorities, with access to SDIs limited to public sector bodies. Soon after, the way in which spatial information was used, produced and shared changed dramatically. The recent evolution and advances in Global Navigation Satellite Systems (GNSS), mobile devices and Global Positioning System (GPS) enabled devices allowed for common citizens to participate in the GI experience (Gómez Barrón Sierra, 2020; Costa Fonte et al., 2017; Budhathoki, 2010), which also became known as Volunteered Geographic Information (VGI) (Goodchild, 2007), such as is the case with the OpenStreetMap (OSM) project.

1.2. Open Spatial Data Infrastructure Ecosystems

Similarly, a new trend for SDIs have emerged as a more 'open' SDI. In an open SDI, citizens, businesses, academics and non-governmental actors can share their data as stakeholders of the infrastructure (Vancauwenberghe et al., 2018; Vancauwenberghe and van Loenen, 2018), while also providing an increased availability for participating in important governance and organisational decisions.

Recently, the public sector has taken the initiative to adopt open data formats to ensure that data are provided for free, are machine-readable, and have no licence restrictions (Vancauwenberghe and van Loenen, 2018). Open formats facilitate the connection of GI with different providers that use the same standards. This enables people to innovate, use or create applications and Application

Programming Interface (API) as they please and to engage in public decisions (Fox, 2013; Varga et al., 2022).

1.3. How can OpenStreetMap contribute to Open SDI research

Citizens can supply valuable VGI to SDIs at a high technical level (Goodchild, 2007), as is the case with OpenStreetMap (OSM). This can lead to improved levels of participation of users in SDIs (Mooney and Corcoran, 2011). The quality of VGI and its integrity has been researched previously (e.g., Mashhadi et al., 2015), as well frameworks to increase contribution to the public sector (e.g., Khan and Johnson, 2020), and the factors to contribute to OSM. However, research into which factors contribute to ensure long-term user participation in Open SDI has yet to be done. We need to understand the status of spatial data in open spatial data infrastructures and to identify the factors that motivate users and how user participation in an open SDI can be assessed properly.

In this article, we answer our research question '*What are the factors that foster user participation in the community of an open SDI*?' Our exploratory research shows how theory can be put into practice to move open SDIs to the next level, as well as to understand how the extrinsic, and intrinsic motivational factors can build, or otherwise hinder, a sustainable participatory community. To do so, we use OSM as a case study to assess key success factors that can be used to foster user participation in open SDIs. We consider the intrinsic and extrinsic factor that motivate user participation in OSM, how and to which extent our selected users participate, and what can be done to motivate the community of users to participate in an open SDI.

2. Literature review into user participation factors

User participation indicates how much people are willing to engage on a personal and organizational level to contribute their knowledge on specific issues. User participation in relation to spatial data contributions vary according to the amount of social pressure to be involved or to have a sense of inclusion in important components within organizations (Montalvo, 2003, cited by Rajabifard et al., 2006). This can result in a limited engagement of the actors that are responsible for promoting data reuse in distinguished initiatives. Other studies have shown that some of the factors that play an important role in open data user participation are mainly the quality of infrastructure. the knowledge shared, the confidence of users in the open data, how useful it was and if it met their expectations (Krismawati and Hidayanto, 2021).

Although OSM is not by any means the sole repository for VGI data, it is one of the most common repositories. OSM was initially created in 2004 to map streets to overcome licensing restrictions of certain maps at the time and to supply crowdsourced geographical information for users (Bennett, 2010). The purpose for which it was made was intrinsically connected to gathering freely provide available spatial data, which was previously restricted for small businesses, individual users and community organizations that could not afford, access or modify the traditional GI that was provided through the data steward (Budhathoki and Haythornthwaite, 2013).

Motivations to contribute to VGI is influenced by the technology that people have available, such as GPS enabled devices, computers storage and processing capacity enable people to feel motivated to voluntarily give their collected data (Tanaka, 2017). The most important component in VGI is the collective effort of the contributors, which differs from the traditional effort to produce spatial

data, since there is no monetary compensation or someone to direct you on how to contribute. This way of producing spatial data resembles a Wikipedia style for generating new information (Budhathoki et al., 2008; Budhathoki and Nedović-Budić, 2010; Tanaka, 2017). According to Nielsen (2006), within online communities and social media, only 1% of people actively contribute, 9% contributes occasionally and 90% of users do not contribute at all and are identified as 'lurkers'. Nielsen (2006) defines this as "participation inequality", and within Wikipedia, this inequality is even more disparaging with 99,8% of the population characterized as 'lurkers' (Sjoukema, 2015).

3. Research methodology

This research used preliminary web-based surveys and semi-structured interviews with users of OpenStreetMap to explore the factors that foster user participation in the community of an open SDI. We used a methodology that adapted motivational factors from Budhathoki (2010). In relation to the motivational factors, intrinsic motivation is derived from inner core values that motivate someone to participate, since it is not reliant on external factors from the outside world, whereas extrinsic motivation is related to tangible external factors that surround us, such as financial rewards or outside recognition (Hennig, 2020). This formed the theoretical framework that was used to development of the qualitative assessment of the user participation for Open SDI. After joining and establishing contact with the community of OpenStreetMap, preliminary surveys were distributed within the active user communities, which were used to contact volunteers for further semi-structured in-depth interviews. Then, a qualitative analysis of the surveys and the interviews was executed to examine what are the key themes, indicators and motivations that were identified from the users to participate in an Open SDI. A total of 100 valid responses from the survey were recorded and 13 interviews were conducted with survey participants who agreed to be interviewed, plus two interviews with academic experts in SDI user participation.

4. Analysis of our research

Our results showed that most survey respondents participate in OpenStreetMap on average at least a few times a week or every day. This highlights that the volunteers that participated in the survey are most likely "heavy contributors" to the project. The main motivations identified in the survey (response rate), were extrinsic factors of believing in OSM's project goal, OSM community and career, and the intrinsic factors of fun, instrumentality of knowledge, and altruism. It is important to mention that users felt very strong about the positive impact the community has, not only in the project, but also as a feedback loop to the open data ecosystem which OSM is a part of. Simultaneously, it was also the main point of improvement for OSM according to some participants. Most of what participants recommended were generalized improvements for new users, like what Budhathoki and Haythornthwaite (2013) describe lightweight organization and collaboration to be. However, it shows that heavy contributors have also lightweight contributor motivations, which differs from what has been shown in the previous studies into motivational factors of OSM.

Mixed feelings were shown in relation to the concern of commercial and institutional influences inappropriately taking over OSM (over the policies, standards and restrictive licensing for external use). This is in alignment with the anti-corporate sentiment presented by Budhathoki and Haythornthwaite (2013) and Budhathoki and Nedović-Budić (2010). Users generally trust the

infrastructure, even though there could be potential improvements and especially the "heavy contributors" feel the trust, design and self-organization in the project, despite the interference of some users who do not follow the guidelines. In general, users understand the benefits of open data within the OSM ecosystem but believe that establishing a harder standard for the OSM data would improve restrictions and licensing barriers for external users (both for the public/private sector and academia). Respondents recognize the role of OSM in the larger open data ecosystem (i.e., public sector, countries, National SDIs) and the open data ecosystem that envelopes OSM data. Both experts and interviewees acknowledge the underlying issues with OSM's licenses and standards, although linked data should be possible, if a direct communication line exists with external stakeholders.

As to how and to what extent OSM users participate in the open data community, most of the survey respondents were users that contribute at least a few times a month and on average a few times a week. This could be either due to users in OSM participating as much, or most likely due to the volunteer bias. Since many users also showed high interest to learn, participants in this research did so because they believed the research addresses important challenges, such as how to maintain motivation in the long-term. Nevertheless, further research could shed light on this matter.

Finally, factors that could foster user participation in an open SDI in general, as proposed by OSM users, are better support mechanisms, tutorials for the multiple editors of OSM as an open SDI and centralization of one main communication channel as a reliable source of information. Moreover, more accessible editing on digital devices would also enhance user participation since users could contribute from more devices. Better user guidelines would also help, not only new users but also already contributing users. OSM is quite a complex platform with many factors that must be considered before adding new data and, therefore, there are guidelines and standards suggested by the community for how to do so in a uniform and accepted way. Currently, users mention that the lack of prescriptive guidelines for adding new data provides such a steep learning curve that not all participants are able to to understand. Hence, a less overwhelming step could be included to bridge this gap either with more tutorials or videos.

5. Conclusion and recommendations

In summary, the belief in the project goal of OpenStreetMap, the perceived importance in the community by the users to the development of OpenStreetMap and its ecosystem, fun, instrumentality of knowledge, altruism, unique ethos, meeting their self-needs and learning are among the most important factors for active users to participate in an Open SDI. To engage both potential new and long-time users in an efficient, user friendly, and a light-weight manner requires balancing priorities in relation to the infrastructure's current status and goals. Maintaining an active community requires engagement on a personal level, where transparent or more enforcing user guidelines would also help not only new users, but also the ones that already contribute. OpenStreetMap is perceived as an Open Data Ecosystem among its users and as an Open SDI amongst the selected experts, yet there were dividing opinions to the perception about Open Spatial Data Infrastructures in relation to OpenStreetMap from their own users. Essentially, by itself, OpenStreetMap provides only map data, which would be another contention point for determining if it is an open SDI, although vector tiles are in development in the OpenStreetMap infrastructure.

Users are free to participate openly in many different fields of OpenStreetMap if desired, i.e., any of the five key components of SDI: standards, policies, access network, data, and governance.

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