Gamification in a Volunteered Geographic Information context with regard to contributors' motivations: A case study of OpenStreetMap

by

Chen Chen

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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ABSTRACT

Volunteered Geographic Information (VGI) describes a new type of spatial information created by the public voluntarily (Goodchild, 2007). However, many questions persist about the quality of VGI, due to a lack of knowledge of quality assurance procedures and credibility of its creators (Flanagin & Metzger, 2008; Haklay, 2010). One solution to quality assurance is to engage more contributors and take advantage of Linus's law that errors are more likely to be fixed given enough eyes on the issue. Gamification, which borrows game elements in non-gaming contexts to increase engagement (Deterding et al., 2011), has been practised to attract more contributors as well as assure the quality of geographic data on OpenStreetMap (OSM). Though gamification has proliferated, there is less research investigating the efficacy of those instances. This study aims to investigate the efficacy of gamification on OSM with regard to contributors' motivations. Through online surveys distributed to OSM contributors, four major motivations to create VGI on OSM were identified: Self-need regarding community, Data Improvement, Monetary Award, and Altruism. By having follow-up interviewees with the participants, the perception of current game elements on OSM as not effective in motivating contribution was recognised. The reasons why the game elements were perceived this way include that these elements were not able to fulfil contributors' motivations. The study demonstrates that simple transfer of game elements in VGI projects such as OSM will not lead to similar motivational affordances and engagement outcomes, and the understanding of motivations to contribute VGI is important for gamification design. In addition, suggestions for engagement on OSM are proposed: gameful experience should be focused if gamification is used; self-policing and appreciation behaviours should be promoted through new features; the humanitarian aspect of OSM should be emphasized to attract more contributors.

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Finally, I would like to express my profound gratitude to my parents for their love, encouragement, and support in all my pursuits.

DEDICATION

I dedicate this thesis to my parents, without whom I wouldn't be who I am today. Thank you for always believing in and supporting me.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Volunteered Geographic Information (VGI) describes a new type of spatial information created by the public voluntarily (Goodchild, 2007). The rapid development of technology has taken down the technical barriers which prevent the public participation in generating spatial information: Web 2.0 allows the public to contribute spatial information by easily tracing aerial images in their armchairs; GPS-enabled mobile devices permit the public to track their locations and conveniently share them on the run. These convenient approaches to creating spatial information have resulted in a considerable volume of spatial information, which can serve as an alternative to traditional spatial dataset provided by either government agencies or commercial organisations.

The quality of spatial information has been the focus of researcher attention since the first definition of GIScience (Goodchild, 1992; Haklay, 2010). The quality of spatial information collected by trained professionals and published by authority agencies is assured since professionals' expertise and authority agencies' reputation enforce them to follow quality assurance procedures controlling the quality (Flanagin & Metzger, 2008). In the contrast, the quality of VGI is always questioned in light of the creators with less knowledge, and the loose coordination of data collection and quality standard (Flanagin & Metzger, 2008; Haklay, 2010). Furthermore, the questions on VGI quality is particularly crucial to the use of VGI in various applications such as navigations. Engaging more contributors to participate in contributing geographic information is a potential solution to quality assurance, and it is also an example of the well-practiced Linus's law within the open source community - errors are shallow given enough eyes (Goodchild & Li, 2012). Haklay et al. (2010) have demonstrated the positional accuracy of a feature improves as the number of contributors the feature exposes to increases through a case study on OSM dataset. The importance of engaging more contributors in quality assurance is also identified by Fritz et al. (2009) as one of the two challenges in VGI context.

Gamification applies game elements in non-gaming systems to enhance user experience and user engagement (Deterding et al., 2011). It aims to impart similar experience and feelings people have when playing games to non-gaming activities by utilising game elements (Huotari and Hamari, 2012). Game elements such as leaderboards and points, which provide users feedback on their performances, are used to encourage continued activities of users in non-gaming systems. The proliferation of gamification instances has been seen in various context, and empirical research

has shown its positive impacts on engaging users (Hamari et al., 2014). For instance, gamification instance such as Foldit, in which people compete for each other solving protein structures, even help to figure out complicated protein structures that scientists are not able to identify (Cooper et al., 2010).

The applications of gamification in VGI context have also been proliferated, and game elements are integrated into various aspects aiming to motivate more contribution as well as to assure data quality. However, simple transfer of game elements in non-gaming context may not lead to similar motivational affordances (Deterding, 2011). Motivational affordances indicate the property of an object that determine whether and how it can satisfy one's motivational needs and thus induce actions from users (Zhang, 2008). When motivational affordances perceived, people are willing to take actions and their motivations are satisfied. Users in non-gaming contexts may not perceive the similar motivational affordances of the game elements as these game elements are originally designed for video games. Thus, it is possible for users not using the game elements, which results in failure of the primary purposes of gamification – engage the user.

Yet despite an increasing number of gamification instances in VGI context, there is a lack of concerns on the efficacy of these instances. Motivational affordance suggests a way to explore the efficacy of gamification in the applied system from the perspective of used game elements. Users' perception of game elements can facilitate to outline the motivational affordances of the game elements, and further guide effective design and implementation of gamification in the future. In this research, a case study on OpenStreetMap (OSM) was used to investigate the impact of gamification elements on user motivations. An online questionnaire was first used to collect quantitative data for identifying major motivations to create geographic information on OSM. Interviews with contributors followed to inquire how contributors perceive current gamifications on OSM. These sources of data were aggregated to investigate current gamifications from the perspective whether the used game elements can satisfy contributors' motivations.

1.1 Research Objectives

In a broad sense, this research used a case study on OSM to investigate main motivations to create VGI and contributors' perceptions of existing gamification to imply the efficacy of current gamification in VGI context. These two goals are addressed by the following objectives:

1. Identify main motivations to create geographic information on OSM
2. Investigate contributors' perceptions of game elements for gamification on OSM
3. Evaluate the efficacy of current gamification on OSM in relation to contributors' motivations
4. Provide suggestions for future gamification and engagement in VGI context

1.2 Thesis Outline

The thesis consists of five chapters. Chapter One briefly introduces the study, identify the research objectives, and presents the outline. Chapter Two, the review of the literature, explores key ideas within Gamification and VGI, and attempts to connect these to the discussion of Gamification in VGI context. Chapter Three explains the research approaches including data collection and analysis methods as well as limitations. Chapter Four presents the motivations identified in the factor analysis, contributors' perceptions of current gamifications on OSM, and suggestions for engagement. Chapter Five connects the results presented in Chapter Four with the academic literature from Chapter Two, and further discuss several key outcomes of the research. Chapter Six will conclude this thesis and present directions for future research.

2. STATUS OF RESEARCH

2.1 Gamification

Gamification is a new concept that arose in recent years. The term was first introduced in the early 2000s, but it only started to gain attention in industry and academia since 2010 (Groh, 2012). It originates from a rapid proliferation of non-gaming systems that take inspiration from video games. Game design elements are borrowed and adopted by applications in non-gaming contexts, and the trend was seen in various fields ranging from education to entertainment media, and is defined using the term 'Gamification' (Deterding et al, 2011). The following section will unpack the Gamification term in further depth from the concept to the mechanics.

2.1.1 Gamification: The Concept

A widely cited definition, "Gamification is the use of game elements in non-gaming contexts", is provided by Deterding et al (2011). The definition situates Gamification within a larger field "Ludification of Culture".

> "Within the socio-cultural trend of ludification, there are at least three trajectories relating to video games and HCI: the extension of games (pervasive games), the use of games in non-game contexts, and playful interaction. The use of games in non-game contexts falls into full-fledged games (serious games) and game elements, which can be further differentiated into game technology, game practices, and game design. The latter refers to 'gamification'." (Deterding et al., 2011, p.5)

The definition relies on the notion that gamification uses game design elements, and also draws distinctions between other related concepts. Figure 2.1 outlines the place where Gamification fits within the field of "Ludification of Culture". Gamification uses game design elements rather than being an extension of games – pervasive games, games that have features expanding play spatially, temporally, or socially such as location-based games and augmented reality games (Magerkurth et al., 2005; Montola et al., 2009). Serious games are full-fledged games for non-entertainment purposes while gamification may only incorporate game elements. Gamification focuses on the use of game design elements instead of game-based technology and game practices.

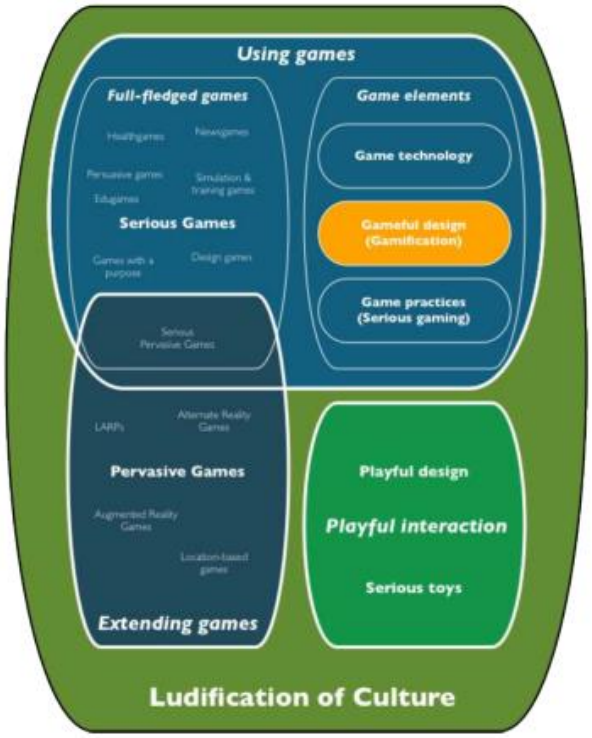

Figure 2.1 Situating Gamification in the larger field (Deterding et al., 2011)

An alternative definition is provided by Huotari & Hamari (2012) from the perspective of service marketing as "a process of enhancing a service with affordances for gameful experiences in order to support users' overall value creation" (p. 19). The definition emphasises the goal of gamification – attempt to give rise to gameful experience – rather than the approaches used (Hotari & Hamari, 2012), and suggests a rule for a system being accepted as gamified. Furthermore, the researchers pointed out that game elements may not automatically create gameful experiences and the definition based on the use of game elements may result in misclassification of systems such as loyalty programs, where elements similar to game elements are applied, into gamified systems.

The two definitions provide important perspectives to outline Gamification. The former by Deterding et al. (2011) emphasises the involved game design elements while the latter by Huotari & Hamari (2012) highlights the outcomes produced – gameful experiences. Both sides argued against each other that the opponent's definition does not outline Gamification from a correct point view and may lead to misinterpreting some systems as gamified. However, the two definitions complement each other to form a more comprehensive view of gamification. The use of game design elements provides a direct and objective way to define gamification that systems integrating qualified game design elements are gamified. On the other hand, the gameful experience is more

of a subjective feeling, and the definition adds consumer and designer's perceptions to define gamification.

2.1.2 Gamification: The Mechanics

The primary goals of Gamification are to motivate user activity and increase retention in non-gaming contexts (Deterding et al., 2011). Such goals are approached through the use of game design elements borrowed from video games to impart gameful experience people have when playing games to non-gaming activities (Huotari & Hamari, 2012). It is the significant influence of video games on engagement that inspires Gamification. According to Neilsen (2014), U.S. gamers age 13 or older spent an average 6.3 hours a week playing video games in 2013. The numbers were 5.6 and 5.1 in 2012 and 2011 respectively. As suggested earlier, Gamification attempts to borrow the power of video games engagement, thus the understanding of video game engagement should facilitate discussion of Gamification applications. Previous research has applied different models to understand video game engagement, and these models will be elaborated in the following part.

Pryzbylski, Rigby, & Ryan (2010) suggested that video game engaged people by satisfying their psychological needs. People play video games, in most cases, out of intrinsic motivations rather than extrinsic motivations such as monetary reward (Ryan, Rigby & Prybylski, 2006). The investigations based on self-determination theory (SDT) have demonstrated that video games could satisfy three basic needs within the theory – competence, autonomy and relatedness – to facilitate intrinsic motivations (Ryan et al., 2006; Przybylski, et al., 2010). SDT provides a framework to address factors that support or undermine motivations suggesting that the three basic psychological needs must be satisfied to foster well-being (Ryan et al., 2006). As for video game engagement, it is also due to that video games satisfy the needs and thus motivate game play (Ryan et al., 2006). The three psychological needs are satisfied differently during game play. Competence describes "a need for challenge and feelings of effectance" (Ryan et al., 2006). Game elements such as tasks offer challenges and opportunities for positive feedbacks, and the interactions with these elements satisfy players' need for competence. Autonomy concerns "a sense of volition or willingness when doing a task" (Ryan et al., 2006). People intend to perceive high autonomy when doing activities for personal interest or value. The use of rewards as feedback and provisions for choices in video games can enhance autonomy, and in turn trigger intrinsic motivation (Ryan et

al., 2006). Relatedness, as the word indicates, describes a need for individuals to find relatedness to others. The opportunities for social interactions provided by video games, especial those multiplayer games, can afford players' need for relatedness.

Yee (2006) investigated video game engagement focusing on motivations of different types of players. The investigation identified three overarching motivations for game players – achievement, socialisation, and immersion, and suggested that the motivations influenced players' activities and behaviours in games. Players with achievement motivation are more likely to care about their progress and power in the game while players with socialisation motivation intend to chat and make friends with other players. The investigation is based on the theoretical work by Bartle (1996), which proposed a taxonomy of players with regard to their motivations in Multi-User Dungeon (MUD), the precursor of nowadays massively multiplayer online role-playing games. Bartle (1996) recognised that there were four types of players: Achiever, Explorer, Socializer, and Killer, and indicated they behaved differently in game play. Achievers consider points-gathering and promoting in levels as their main goal; Explorers fascinate about discovering internal machination of games; Socialisers show interests in other players and tend to make friends and chat with others; Killers get their fun from attacking others (Bartle, 1996). Kim (2012) developed another taxonomy based on Bartle's type that better describes primary motivational patterns in nowadays more casual and social games, and "social engagement verb" - *Compete*, *Express*, *Explore*, and *Collaborate* – are used to label different types of players. *Compete* type of players, similar to Bartle's Achiever, enjoys competition with others and improvement of their metrics; *Collaborate* type of players, similar to Bartle's Socializer, enjoys collaboration with others in the games; *Explore* type of players, similar to Bartle's Explorer, enjoys exploring every aspects of the games; *Express* type of players, as a replacement for Bartle's Killer, enjoys self-expression and showcasing their abilities (Kim, 2012). These works also demonstrated that elements in games provided opportunities for players satisfying their own unique motivations, and the satisfactions of their motivations in turn engaged them in continuous game play.

The investigations based on SDT address the psychological need satisfactions underlying video game engagement while theoretical and empirical works focusing on motivations of video game address motives deduced from the affordances provided by video games (Przybylski et al., 2010). These provide two models to explain how video game engagement works. The former model

indicates that the satisfaction of individual's innate needs – competence, autonomy, relatedness - are the fundamental reasons for game play and explains how these needs are satisfied by elements and factors within the game. The latter model has demonstrated the variety of motivations underlying video game and suggests that different motivations lead to a variety of players' activities and behaviours. Players' activities and behaviours in games are associated with their interactions with game elements, thus the influence of motivations on players' activities and behaviours should also be reflected in players' perception of and interaction with game elements.

2.1.3 Motivational Affordances

The understanding of video game engagement suggests that a variety of motivations may influence players' perception of and interaction with game elements. As mentioned earlier, players with Achievement motivation strive for accumulating achievements in games, for instance, levels that indicate players' progress and powers in games. However, this type of players may not be really interested in chatting and making friends with other players unless it helps gain more achievements. This implies that the influence of game elements on engaging players may vary according to players' motivations. This concerns the use of Gamification as it uses game elements to increase user activity and retention.

The consideration of a variety of participants in a gamified system with regard to their motivations during the gamification design process is recognised by researchers. Dixon (2011) purposed the integration of knowledge on player type into the design process of gamified systems suggesting the importance of considering a variety of participants. The researcher suggested that the design process should refer player types for effective gamification (Dixon, 2011). The recognition also led researchers to take inspirations from research in human and computer interaction suggesting that game elements should have motivational affordances. Affordance describes the actionable property of an object and actor, and when received it satisfies actors' particular needs and induces actions (Zhang, 2008). Motivational affordance, as the name suggests, is the property of one object that depicts whether and how it can satisfy one's motivations (Zhang, 2008). In the case of gamification, game design elements with high motivational affordances should be used to increase user activity and retention. Game design elements with high motivational affordances should satisfy participants' motivational needs, and thus induce their actions and increase engagement. Weiser et al. (2015) proposed a taxonomy of motivational affordances for meaningful gamification

grounded on motivations. The taxonomy demonstrates how a gamification instance should be designed to address users' motivations, and depicts how engagement functions from lower level game elements implementing mechanics to achieve higher level general design principles. The research provides a reference on how basic psychological needs described in SDT and motivations are addressed using various game elements.

Motivational affordance of an object may be perceived differently due to the context that the object is applied. Game elements are originally designed for game players, and the significant impacts of game elements on engaging players indicate high motivational affordances of the elements. However, these high motivational affordances are for players with motivations such as achievement, socialisation, and immersion according to Yee's empirical work (2006) and Bartle's type (1996). However, those game elements may not have high motivational affordances when they are applied in a non-gaming context where motivations are not achievement, socialisation, or immersion. Deterding (2011) suggests that simple transfer of game elements from play context into another usage context may not lead to the same motivational affordances. In order to better use game elements to increase user activity and retention, it is necessary to consider situated motivational affordance. Deterding (2011) defines situated motivational affordance as "opportunities to satisfy motivational needs provided by the relation between the features of an artifact and the abilities of a subject in a given situation, comprising of the situation itself (situation affordances) and the artifact in its situation specific meaning and use (artifactual affordances)" (p.3). This definition emphasises the importance of situation or context in shaping the motivational affordance of game elements. A context where gamification applies may have motivations dissimilar to the motivations in a video game, and these motivations and their impacts on the use of game elements should be concerned.

2.2 Volunteered Geographic Information

Volunteered Geographic Information (VGI) defines a new type of geographic information due to the development of technology. Web 2.0, Global Positioning System (GPS), and mobile technology offer the public opportunities and abilities to create geographic information. The participation of the public introduces a large volume of various geographic information into traditional geographic information and also initiates issues and challenges. The following section will present previous research relevant to the reasons why gamification is proposed for VGI

context as well as concerns on motivations in VGI context for effective gamification following the concept of situated motivational affordance presented in the previous section.

2.2.1 The fit of Gamification in a VGI context

The development of the web and mobile technology in the past two decades gives rise to user-generated content which denotes the information produced by the users. The distinction between users and publishers of web content is blurred as the new technology offers users the abilities to conveniently create and share content. VGI is user-generated content in a geographic information context (Goodchild, 2007). The production of geographic information was previously exclusive to geospatial specialists who are well-trained in state of the art technology creating geographic information. However, nowadays GPS-enabled mobile devices and Web 2.0 bring down the technical barriers and allow the public to create geographic information.

The rise of VGI benefits the collection and maintenance of geographic information. The development of technology has expanded the sources of geographic information as every citizen is able to participate in the creation process. Instead of relying on professionals, the collection can be crowdsourced to a huge network of citizens, and such crowdsourcing approach can accelerate the collection process. Furthermore, the ground features on earth surface change frequently, which requires a frequent update of relevant geographic information for accuracy. The introduction of citizens into the creation process definitely facilitates fast response to the changes of features and maintains the quality of relevant geographic information. Fritz et al. (2009) investigated the use of crowdsourced VGI in validating global land cover maps and demonstrated the great potential of it.

The participation of the public in creating geographic information also introduces challenges. Fritz et al. (2009) suggested that one of two challenges for VGI were to be able to guarantee its quality. The quality of VGI is questioned due to the creators. The credibility of the geographic information created by well-trained geospatial professionals is granted as the creators are perceived as experts in terms of their relevant skills and knowledge (Flanagin & Metzger, 2008; Goodchild, 2008). The creators of VGI are the public whose skills and knowledge in creating geographic information is doubted, and the quality of geographic information produced by them is in turn questioned. In addition, unlike traditional authoritative geographic information whose creators make efforts assuring its quality, VGI does not assure its quality (Goodchild & Li, 2012), which also naturally induces concerns on its quality.

In the face of the concerns on VGI quality, quality assurance approaches on VGI have been investigated. A crowdsourced approach among other approaches has been proposed by many researchers. The approach is based on Linus's Law that originates from Open Source Software community. The law suggests that errors are discovered and corrected if they are given enough eyes (Goodchild & Li, 2012). In the case of VGI, which involves volunteer contributors as Open Source Software development does, the crowdsourced approach should be also effective in correcting errors for improving data quality. The efficacy of the approach assuring VGI quality has been demonstrated by investigations on OSM data quality. Haklay et al. (2010) suggested that OSM dataset reached a locational accuracy of 6m beyond 15 contributors per square kilometre, which demonstrated the applicability of the crowdsourced approach. However, as indicated in the research, the efficacy of the approach relies on sufficient eyes. Goodchild & Li (2012) examined Wikimapia and suggested that errors would be missed due to that few contributors had reviewed them. This imposes a challenge that is also suggested by Fritz et al. (2009) - to engage a wide range of volunteers who like to contribute geographic information. Through engaging more contributors, errors are more likely to be fixed, and thus the quality can be assured. Gamification is appropriate for attracting volunteers to contribute geographic information. As suggested earlier, the objective of Gamification is to engage users. Through the use of game elements, contributors may gain gameful experiences during the creation of VGI, and thus get continuously engaged in creating more. The increase of user engagement will result in more eyes on errors and in turn corrections of them.

2.2.2 Motivations in VGI context

The importance of situated motivational affordance for the efficacy of gamification has been outlined in the previous section. The motivations in a non-gaming context where gamification applies have significant impacts on how users perceive used game elements, which in turn influences whether these game elements are able to engage users. In this section, literature on motivations to contribute VGI will be explored. The knowledge of these motivations can provide a foundation for the investigations in this study.

VGI denotes geographic information contributed in a voluntary manner, and such voluntarism can coordinate a network of participants all over the world to collaboratively create web maps as detailed as OSM. It naturally prompts questions: what motivate participants to contribute

geographic information even though no monetary rewards are awarded? Having similar questions, researchers have identified various motivations in previous studies.

Early explorations on motivations in VGI context are based on summarising and consolidating literature in fields that share similar characteristics with VGI context. Coleman, Georgiadou, and Labonte (2009) proposed a taxonomy of motivations in VGI context based on previous empirical research studying voluntary contributors in Wikipedia and Free or Open Source Software. These motivators contain both those which provoke constructive contribution and those which provoke destructive contribution. The former ones include *Altruism, Professional or Personal Interest, Intellectual Stimulation, Protection or enhancement of personal investment, Social Reward, Enhanced Personal Reputation, Provides an Outlet for creative & independent self-expression,* and *Pride of Place*; and latter ones include *Mischief, Agenda,* and *Malice and/or Criminal Intent*. Budhathoki, Nedovic-Budic, and Bruce (2010) also inquired about motivations in VGI context by drawing knowledge from literature in volunteering, leisure study, and social production of knowledge, and the study listed a number of motivators for VGI along with their conceptual definitions. The researchers classified the motivations into extrinsic and intrinsic types. Intrinsic motivation refers to gaining inherent satisfaction resulted from doing an activity, and extrinsic motivation, in contrast, refers to gaining separable outcomes from the performance of an activity (Ryan & Deci, 2000). For instance, *Altruism* and *independent self-expression* are examples of intrinsic motivations, and extrinsic motivations are like *Enhanced Personal Reputation* and *Professional Interest.* Intrinsic and extrinsic motivations are different from each other, but neither of the two is exclusive to each other. For instance, in OSM, some contributors create road networks for the interest of improving routing function, and they also want to get noticed by potential employers through the process at the same time. It is also suggested by Budhathoki et al. (2010) that intrinsic motivations were prominent in online knowledge communities including in numerous instances of VGI.

The pioneering research provided initial insights into motivations in VGI context, and empirical research followed to investigate the proposed motivations. Coleman et al. (2010) conducted qualitative research to investigate their proposed motivations in VGI instances. The research investigated participants' motivations in three VGI projects - Victoria DSE Notification and Editing Services, USGS National Map Corps, and TomTom MapShare, and confirmed the

motivations identified in their previous study suggesting that contributors in VGI were motivated similarly to other user contribution systems. Budhathoki & Hayhornthwaite (2013) used quantitative approaches extracting seven main motivations from a survey on OSM contributors: monetary reward, learning, self-efficacy regarding local knowledge, project goal, altruism, personal promotion, and personal need. The use of statistical approach consolidated a larger set of motivations identified in previous qualitative research into a smaller set of motivations that were believed to represent the motivations of most contributors in VGI context.

From the perspective of motivational affordance, game elements applied in a VGI context should afford contributors' motivations, if not, contributors may not be motivated by the elements and thus not be engaged. The knowledge on motivations to contribute VGI will facilitate the investigations on gamification in VGI context.

2.2.3 Gamification in VGI context

Previous research has outlined that the efficacy of gamification relies on whether used game elements can afford the motivations of the users in the non-gaming context and suggested the consideration of the motivations in the context was important for effective gamification. Following the successful applications in another context, gamification has also been investigated and practised in a VGI context. However, though many gamification instances aiming to engage contributors have been developed, it seems that the designs of these instances do not take the motivations to contribute VGI into consideration, which results in less effective impacts that those instances have on engaging contributors.

VGI contribution can be classified into active and passive types according to whether contributors consciously create geographic information (Haklay, 2013). Active contribution denotes the VGI created by contributor consciously. For instance, on OSM, contributors are aware of their creation of geographic information, and their main activities are contributing geographic information. The passive contribution is geographic information such as running and biking trajectories collected by Strava. Strava is a mobile application that facilitates users to track their running and biking activities, and it records users' moving trajectories during their activities. People in most cases use Strava to help them reach health-related goals, and geographic information such as moving trajectories are created as by-products. Gamification can be used to engage users creating both types of VGI. However, gamification for active contribution will be focused in this study while

that for passive contribution will not be discussed since the latter one should be regarded as gamification in other usage context rather than VGI context. Strava also adopts game elements engaging its users to run and bike more, and thus longer running and biking trajectories are collected. However, the application cannot be regarded as a gamification instance in VGI context since the users' motivations are not related to contributing VGI though more VGI may be created due to the introduction of game elements. Therefore, it is more likely to consider Strava as a gamification instance in exercise and health context rather than an instance in VGI context. This research aims to investigate gamification from the perspective of motivations, thus it is worthwhile focusing on gamification on VGI of active type. Only instances on active contribution of VGI are outlined in the following section to provide an insight into current gamification in VGI context as well as adopted game element.

Kort is an OSM based application that gamifies the process of modifying and updating OSM dataset. Players receive 'quests' that ask them to populate attributes of ground features such as roads and buildings around the locations of the players, and they receive points for finishing the 'quests'. Urbanology is a mobile game that imitates the design of board game "Monopoly", and it aims to verify and correct OSM data. Players in the game are able to buy venues using the money they earn through finishing tasks such as verification and correction of OSM data (Celino et al., 2012). MapRoulette is an OSM based web application that presents map errors as challenges for users to fix. Missing Maps is another OSM based web application that records participants' contribution statistics and places them on the leaderboard. Participants compete against each other on contributing more to OSM to promote their standings on the leaderboard. Martella et al. (2015) provided a gamification framework for VGI relating knowledge in player type and motivations to contribute VGI in gamification design in the context. An empirical experiment was also done to examine the efficacy of gamification guided by the framework suggesting that more future investigations are required to provide enough grounds for the use of the framework.

Most of current gamification instances in VGI context are based on OSM, which is definitely the most successful VGI project by far. It is noticed that most used game elements are points, challenges, and leaderboards, which are also commonly seen in gamification instances in other non-gaming contexts. The use of these game elements seems to attempt engaging users through making them feel motivated through accumulation of points or competition. As suggested earlier

by research on motivational affordances, it is uncertain that contributors will be motivated by these game elements since the motivations to contribute VGI may not be afforded by the game elements. Hence, corresponding research that investigates the efficacy of gamification in VGI context from the perspective of motivational affordance is definitely required.

2.3 Summary of Literature Review

Gamification is to use game elements to increase user engagement and retention in non-gaming contexts (Deterding et al., 2011). It attempts to impart gameful experience that players have in games to non-gaming systems. The use of gamification in VGI context is expected to engage contributors to assure data quality as well as to create more geographic information.

The efficacy of gamification relies on high motivational affordances of used game elements, and users' motivations in the applied context have impacts on the motivational affordances. Previous research has provided an initial knowledge on motivations to contribute VGI, and this knowledge should facilitate assessing the motivational affordances of game elements applied in VGI contexts.

Gamification instances have been practised in VGI context along with investigations on their design. Most of current instances and investigations focus on OSM as it is the most successful VGI project by far. The commonly used game elements such as points, challenges, and leaderboards are also used to encourage contribution to OSM. However, both the practices and investigations seem not to take motivations to contribute VGI into consideration, which concerns whether these gamification instances are effective in engaging contributors to create VGI and induces this study which aims to investigate the efficacy of current gamification on OSM.

3. RESEARCH APPROACH

This research adopted a combination of both quantitative and qualitative approaches to answer the research questions. The use of factor analysis- a quantitative approach - has the advantage of recognising factors that are difficult to observe otherwise from measurable variables (Gorsuch, 1974). On the other hand, qualitative approaches – particularly thematic analysis – facilitate a better understanding of contributors' perceptions of gamification from the interviews. The two approaches complement each other to present diverse perspectives of the investigation.

In carrying out this research, an online questionnaire was first sent out through OSM *Talk* email list, and follow-up interviews were then held with interested OSM contributors. The online questionnaire provided quantitative data for factor analysis to extract motivations as well as brief insights into contributors' perceptions of current approaches to gamification. Interviews with several contributors served as primary sources for a deeper understanding of the perceptions relating them to contributors' motivations. The complete procedure of collection and interpretation of the data is further explained in following sections.

3.1 Methods of Data Collection

In order to address the research objectives, a variety of quantitative and qualitative data were collected. Quantitative data consisted of coded numerical values collected using the online questionnaire. The qualitative data consisted of transcripts of semi-structured interviews held with contributors on OSM. The following sections will discuss how participants were recruited for both the online questionnaire and interviews as well as the development of online questionnaire items and a semi-structured interview guide.

3.1.1 Recruitment

The goal of recruitment in this research was to acquire a sample of contributors whose feedbacks on the study subject would produce findings that can be generalised to the whole OSM community, and in other words, the participants in the research had to be representative of the community. The most intuitive approach would be to randomly select a sample from the whole population of the community. The approach would require identity information of the whole population, and then a random selection strategy would be applied to draw a sample. However, the identity information of the whole population of the OSM community is not explicitly available, and it requires accessing

to all the created geographic data in order to acquire the identity information. Budhathoki (2010) has suggested such an approach recruiting participants from OSM community by first acquiring user names of all contributors. As OSM provides a free downloadable geographic database, the approach first downloads geographic database to a local database and extracts the user names of contributors from every single data piece in the database. Then, contributors were reached out to through the messaging function on OSM using scripts. However, the approach may not be effective if it were applied in this research considering that there is a huge increase of register users and an existence of less-active contributors. When this approach was applied in 2009, OSM had about 120,000 registered users, and the downloaded database contained 800 million records (Budhathoki, 2010). According to the statistics on the OSM Wiki page (OpenStreetMap, n.d.), the accumulated registered users has reached 3 million, along with the number of node and way creation passing over 3,750,000,000. Budhathoki's approach would still work, but hardware resources for processing this amount of geographic data is challenging to acquire. Moreover, the OSM community, like other online communities, consists of active participants, somewhat active participants, and also one-time participants, and the status of their activities determines their experience level with OSM. Though this research should try to reach every contributor regardless of their experience and does not explicitly require participants of the study to have a certain level of experience, it can be assumed that less-active contributors will not have an opportunity to see the recruitment materials during the research time frame nor be interested in participating this research. The two aspects mentioned above both suggest an alternative approach for this research.

OSM provides mailing lists for contributors to facilitate communication. Subscribers initiate and discuss various issues on different email lists according to the topics. The *Talk* email list happens to be a desirable recruitment channel since it is designated for general discussion of every aspect of OSM, hence subscribers to the email list should be interested in participating this research. Moreover, it is expected that more interesting and insightful responses will be gathered from the subscribers since they should be more active contributors with experience in various perspective of OSM.

Two stages of recruitment were used: one for the online questionnaire and one for the interview phases, and they were implemented at different times. The first stage happened when a recruitment email that contains a link to the online questionnaire was sent to *Talk* email list. Subscribers could

either choose to answer the questionnaire or refuse to answer. Interested participants to the follow-up interviews were asked to indicate their willingness and to provide their contact information at the end of the online questionnaire. The second stage happened when recruitment messages were sent out to those interested participants to the follow-up interviews. The potential interviewees were contacted and confirmed with their available time for interviews.

3.1.2 Online Questionnaire

In order to collect data for addressing the research questions, a researcher-administrated online questionnaire was first used (Appendix A). The questionnaire focused on collecting quantitative data that indicates contributors' motivations and their attitudes toward current gamifications while also gathering quantitative data on what people perceive helpful using current gamifications. The reasons why a researcher-administrated online questionnaire was selected as an instrument are as follows: the online questionnaire is convenient for interested participants that it does not require too much time commitment from participants, and the collection and processing of a considerable amount of responses is thus faster.

The online questionnaire consisted of 3 sections. The first section asked participants to indicate their agreement with items that describe various motivations for their contribution to OSM. Previous qualitative research has provided general implications into the motivations on contributing to OSM (Coleman et al., 2009; Coleman et al., 2010; Budhathoki et al., 2010; Budhathoki et al., 2013), and these works have been discussed previously. The development of the items in the first section was based on the implications of these previous works, and most items were created by customizing sample items provided by Clary et al. (1998) and Gould et al. (2008) or replicating the survey created by Budhathoki et al (2013) with modifications. New items were also developed where no available items existed. The source for each item is given in Appendix A. The answers to the items in this section were first coded and analysed to extract motivations in subsequent factor analysis. The second section focused on how participants perceive current gamifications, and collected both quantitative data and qualitative data. Options given to items used to collect quantitative data in the first two sections are provided in a 7 level Likert scale, and thus participants' answers could be conveniently coded into 1 to 7 to reflect agreement or feelings with items. The third section collected characteristics of participants including age, gender, countries they reside in, how frequently they contribute to OSM, how long they have been

contributing, and so forth. The data collected in this section was not used for subsequent analysis but discussed along with limitations of the adopted research approaches and produced research findings.

3.1.3 Interview

In order to gain deeper insight into how contributors perceive current gamifications, semi-structured interviews were conducted. The online questionnaire provided statistics describing a general insight into contributors' perceptions, however, details about such perceptions are required for a better understanding in relation to contributors' motivations. A semi-structured manner rather than an unstructured manner was adopted for the interviews since the former leaves freedom for interviewees to interpret issues and problems themselves while still focusing on specific topics (Byrman et al., 2009). This approach was used to explore general issues related to OSM while still concentrating contributors' perceptions of gamifications on OSM. To implement the semi-structured interviews, an interview guide (Appendix B) that contains key questions and topics was prepared. When interviewing participants, questions did not follow the exact order on the guide, and some questions not on the guide were asked following some interesting points made by interviewees. There were 14 participants who had identified their interests in an interview discussing their experiences with OSM and gamification related issues. All 14 participants were contacted and provided detailed information about the interviews, and 4 of the 14 participants replied recruitment emails and had individual interviews with the researcher. The interviews were held via Skype either in a manner of video or voice calling since recruited interviewees reside in areas far from where the researcher reside. A time commitment of approximately 60 minutes was required from every interviewee.

3.2 Methods of Data Interpretation

The research collected data in two different formats, and correspondingly, two data analysis approaches were adopted. Factor analysis was applied to the quantitative data collected in the first section of the questionnaire to identify contributors' motivations. Motivations to contribute to OSM are complicated, and the identification of them is thus difficult. Factor analysis suggests an exact corresponding strategy that helps to extract critical unmeasurable constructs, such as motivations, beneath manifesting variables (Gorsuch, 1974), and the approach also provides statistics that help to interpret the extracted constructs. For qualitative data, transcripts of

interviews, thematic analysis was used to build themes regarding contributors' perceptions of current gamifications and related issues. The thematic analysis offers an accessible and all-purpose approach to interpreting qualitative data (Braun & Clarke, 2006). The use of thematic analysis in this study helped to identify potential patterns that could emerge from interviews and develop them into themes that summarised the key knowledge lying in the qualitative data.

3.2.1 Factor analysis

Factor analysis is a widely applied statistical technique in social science. It offers an approach that extracts a smaller set of latent factors from a larger set of observed variables (Costello & Osborne, 2005; Zygmont & Smith, 2014). Each observed variable, through statistical procedures, becomes a linear composite of several latent factors, and the number of factors is smaller than that of observed variables. The use of factor analysis by researchers is to develop a number of dimensions representing the relationship between real-world phenomena and observed variables (Zygmont & Smith, 2014). A major objective of scientific activities is to summarise empirical relationships among observed events efficiently and make general statements using theories; and a primary use of factor analysis is to facilitate the development of the theoretical constructs from empirical data (Gorsuch, 1974). For instance, researchers observed various motives suggested by contributors as to why they created geographic information voluntarily, and they sought for theories that generalise these motives into more general psychological constructs – motivations. Factor analysis, as suggested earlier, is one approach to identifying the motivations based on the empirical observations. In the case of this study, the use of factor analysis facilitated the extraction of motivations from participants' responses to the items in the online questionnaire that measure their motives to contribute to OSM. Each latent factor that emerged from the factor analysis represents a scale for a motivation to contribute to OSM.

3.2.1.1 Preprocessing

The original dataset for factor analysis consisted of participants' answers to items (Section 1 in the online questionnaire) that described their motives to contribute to OSM, and these answers were recorded on a 7-level Likert scale ranging from Strongly Agree to Strongly Disagree. In order to apply factor analysis on the dataset, the answers were first coded into numerical values from 1 to 7 using Excel. In the face of empty answers, a strategy of listwise deletion was adopted. The strategy excludes an individual's answers from the analysis if the individual has an empty answer

for any items, and according to Zygmont and Smith (2014) this strategy should lead to more unbiased estimates.

3.2.1.2 Procedure

The use of factor analysis in exploring motivations has been demonstrated by previous research (Budhathoki & Haythornthwaite, 2013; Yee, 2006), and they provided a general guide to follow. The procedure to implement a successful factor analysis has been well studied by researchers (Costello & Osborne, 2005; Zygmont & Smith, 2014), and it consists of 5 steps (Figure 3.1): test of sampling adequacy, selection of extraction method, determination of the number of factors to retain, selection of rotation method, and interpretation of the factors. In the following sections, these steps will be elaborated in detail, and the justifications for choosing the specific method in this study over other methods are also given.

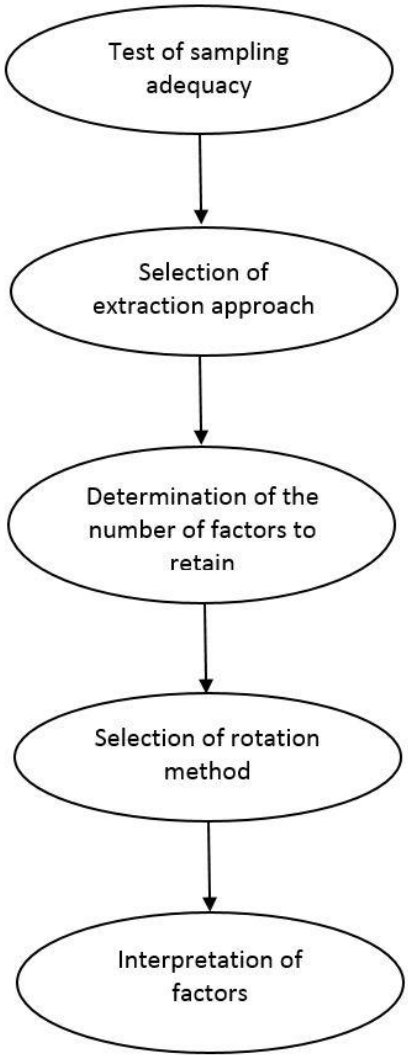

Figure 3.1 A 5-step Factor Analysis Procedure

Test of sampling adequacy examines the used dataset to determine whether a factor analysis can generate significant outcomes. Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity are two of the most used tests for sampling adequacy, and the KMO index is particularly recommended when the response to variable ratio is less than 5:1 (Williams et al., 2010). The response to the variable ratio of the used dataset in this research, approximately 2:1, is less than 5:1, which suggests the use of KMO index. The KMO index ranges from 0 to 1 with 0.5 as a lower boundary for the used dataset being considered adequate (Williams et al., 2010). The Bartlett's Test should also produce a p-value smaller than 0.5 for factor analysis (Williams et al., 2010).

The objective of factor extraction is to reveal the factor structure, which describes each observed variable as a composite of latent factors. To better present this process, the following equation will give a general idea what this process aims to reach:

$$Z_{nv} = F_{nf} P'_{fv}$$

(Eq. 3.1)

Z_{nv} denotes a standard score data matrix for *n* individual on *v* variables; F_{nf} denotes a $n \times f$ matrix describing the scores of *n* individuals on *f* factors; P'_{fv} denotes the transpose of P_{vf} which describes a factor pattern matrix containing the weights to reproduce the *v* variables from the *f* factors (Gorsuch, 1974). The factor structure mentioned above is revealed through calculating a pair of P'_{fv} and F_{nf} that fits the equation when Z_{nv} is known. The equation has an infinite number of solutions when both *P* and *F* are being solved simultaneously, and no unique solution exist unless restrictions are placed on the solution (Gorsuch, 1974).

The selection of extraction method is to place appropriate restrictions for producing a unique solution. There are numerous extraction manners: principle component analysis (PCA), principle axis factoring (PAF), image factoring, maximum likelihood, alpha factoring, and canonical (Gorsuch, 1974). According to Williams et al. (2005), PCA is one of the most widely used methods in the published literature, and also the default method in many popular statistical packages. Moreover, Gorsuch (1983) also recommended the use of PCA when no existing theory or model existed. Therefore, PCA was used to extract factors in this research. PCA uses a full component model - each observed variable is a composite of a small set of common factors without unique factor (Gorsuch, 1974) – to extract factors. The extracted factors from PCA are uncorrelated to each other, and each successive factor accounts for the maximum possible amount of the variance of the variables being factored (Gorsuch, 1974). The extracted factors provided an initial insight into the factor structure of the used dataset, however, further processes are required on the extracted factors to discover what motivation these factors imply.

As suggested earlier, the major use of factor analysis is to find a smaller set of latent factors delineating the information contained in a larger set of observed variables. The delineation is achieved through a determination of the number of extracted factors to retain that a maximum information measured in observed variables can be reproduced from a limited number of factors

(Gorsuch, 1974). The use of factor analysis in this study was to achieve the objective to explore the major motivations to contribute to OSM, and a determination of the factors to retain facilitated the identifications of major motivations that encourage voluntary contribution on OSM. There are mainly two ways to determine the number of factors to retain: determine according to eigenvalues and determine according to scree test. The former way is the default approach in most statistical packages, and it retains all factor with eigenvalues greater than 1 after extraction. However, this approach, according to Costello and Osborne (2015), retains too many factors. The latter way is scree test in which the graph of the eigenvalues is examined to find the natural blend or break point where the plot flattens out (Costello & Osborne, 2005). In this study, the scree test was used to determine the number of factors to retain.

The next process is rotation, and the process aims to simplify and clarify the factor structure upon which meaningful interpretation of the extracted factors can be drawn (Costello & Osborne, 2005). There are two types of rotation: orthogonal rotations and oblique rotations. The former ones produce uncorrelated factors while the latter ones result in correlated factors. The use of orthogonal rotations is commonly advised by researchers since they produce more easily interpretable factors (Costello & Osborne, 2005). However, the researchers also suggested that correlations were expected among factors in social sciences since "behaviour is rarely partitioned into neatly packaged units that function independently of one another" (Costello & Osborne, 2005, p. 3). Therefore, the use of oblique rotations is recommended. As the case of this study, the motivations to contribute to OSM cannot be assumed to function independently either since there is no prior knowledge on the exclusiveness among the motivations, which suggests the suitability of oblique rotations for this research. There are also several methods of oblique rotations: direct oblimin, quartimin, and promax. According to Fabrigar et al. (1999), there is no broad consensus on the most preferred method of oblique rotation, and all methods should produce similar results. In this research, direct oblimin was used to rotate factors in SPSS using a delta value of 0, which is suggested by Harman (1976) for practical purposes.

The final process of factor analysis is the interpretation of factors. The process involves examining which variables are attributable to a factor and labelling that factor with an appropriate name (Williams et al., 2010). The attributes are reflected by the loadings that factors have on each variable in the produced factor pattern matrix after rotation (see Table 4.4), and a salient loading

is commonly required for a factor being considered an attribute to a variable. “A salient loading is one which is sufficiently high to assume that a relationship exists between the variable and the factor” (Gorsuch, 1974, p. 184). A salient loading value of 0.3 or 0.4 is widely recommended by previous research (Zygmont & Smith, 2014), however, the choice of the value also depends on the sample size – smaller the sample size higher the salient loading required (Gorsuch, 1974). This study collected a relatively small sample (35), thus the salient loading was set at 0.5 to compensate potential insignificance caused by the small sample.

3.2.1.3 Reliability Test

Reliability test focused on the internal consistency among the variables attributed to each factor. The internal consistency describes the extent to which all the variables, which a factor loads on, measure the same factor (Tavakol & Dennick, 2011). In this research, Cronbach’s Alpha was used after the interpretation of the extracted factors to suggest the internal consistency (see Table 4.5). The index ranges from 0 to 1, and the closer the value is to 1 the greater the internal consistency of the variables attributed to the factor (Gliem & Gliem, 2003). A value of 0.7 to 0.95 is recommended as acceptable by many researchers (Tavakol & Dennick, 2011). A low value of Alpha could be due to a low number of variables or poor interrelatedness among them while a high value may suggest potential redundancy of the variables (Tavakol & Dennick, 2011).

3.2.2 Thematic Analysis

Thematic analysis is an approach for identifying, analysing and reporting themes within qualitative data (Braun & Clarke, 2006). The approach makes an independent and reliable qualitative approach itself and also has been a critical component for conducting other forms of qualitative analysis (Vaismoradi et al., 2013). Thematic analysis is accessible as the use of the approach does not require integrating any pre-existing theoretical knowledge, which suggests that it can be applied within different theoretical frameworks (Braun & Clarke, 2006). The flexibility of using thematic analysis comparing with other qualitative analysis approach suggest it is a fit to the research considering the novelty of the study subject.

The complete procedure for implementing the thematic analysis in this research consisted of the following steps. Firstly, the recordings of interviews held with participants were transcribed into scripts on which thematic analysis was actually conducted. The information retained in a way that “at minimum it requires a rigorous and thorough ‘orthographic’ transcript” – a ‘verbatim’ account

of all verbal utterances" (Braun & Clarke, 2006, p. 88). Secondly, the transcripts were then analysed following an iterative procedure: generating initial codes, searching for themes, and reviewing themes. Codes that describe contributors' experience on OSM as well as other statements that appeared interesting were first generated. For instance, interviewees may describe how they are motivated by leaderboards to create more contributions, and the particular data extract will be coded for "motivated by leaderboard" and "enjoy the competition environment created by gamifications". The codes reorganise the data into groups that identify contributors' different experiences on OSM. Then these different codes were analysed again to form overarching themes that imply contributors' perceptions of gamifications on OSM as well as related issues. The themes were reviewed and refined that similar themes collapsed into each other and data extracts under themes were coherent. The themes were finally defined and named to describe what the themes were about according to code names and related data extracts.

3.3 Limitations

The research approaches have been given thorough considerations, however, potential limitations of research findings can be estimated because of the adopted approaches. The limitations mainly result from the use of recruitment and analysis methods in this research.

3.3.1 Limitations of Participant Recruitment

The recruitment method could result in less representative participants. First, recruiting participants through *Talk* email list excluded some contributors on OSM from participating the research. Those who do not subscribe to the email list had no chance of receiving the recruitment email and thus were not able to provide feedbacks on the subject of the research. Contributors who subscribed to the email list can be assumed to have more experience on OSM than those who do not. The subscriptions to the email list demonstrate interests in various perspectives of OSM, and these interests can be interpreted as a result of subscribers' passions about OSM and considerable experience with OSM. However, the research findings would be biased as they were based on feedbacks from contributors with rich experience, and this consideration was supported by the data collected for how long and how often the participants have been contributing to OSM. Second, most participants to the online questionnaire come from the United States of America and Europe. *Talk* email list is supposed to be an email list where contributors across the world discuss general issues related to OSM, however, the data on countries contributors reside collected in the third

section of the questionnaire suggests that few contributors from Asia, Africa, and South America subscribe to the email list. This suggests that the produced research findings may be biased since they were based on feedbacks from contributors mostly residing in U.S.A and Europe.

3.3.2 Limitations of Factor Analysis

The type of factor analysis applied in the research also introduced limitations to the research findings, and these limitations mainly come from the extraction approach and decision on the number of factors to retain. PCA assumes that all variables are composites of several common factors (Gorsuch, 1974), and no variable has unique factors. The use of this manner established an implicit assumption that the items in the first section of the questionnaire represented compounds of several common motivations without considering the existence of potential unique motivations. The items were developed based on the motivations derived from previous research, however, there may exist unique motivations that were not identified in those previous research. In addition, as a project that developed rapidly in recent years, many new initiatives were happening around OSM, and new motivations might also appear and some of them might be unique ones to some items. The use of such extraction manner ignored unique motivations. To determine the number of factors to retain is always subjective (Gorsuch, 1974; Williams et al., 2010), and researchers (Costello & Osborne, 2005) suggested an iterative approach to testing out several different numbers for the best one. In this research, a scree test was used to determine the number, and the researcher did go through several repetitive processes until a final number was determined, which could introduce researchers' bias into the findings.

3.3.3 Limitations of Thematic Analysis

The flexibility of thematic analysis allows researchers to analyse a wide range of topics emerging from the data, however, it is also the wide range that may paralyse researchers to focus on a specific aspect of the data or interpret beyond mere description (Braun & Clarke, 2006). The use of thematic analysis in this study facilitated the exploration of contributors' perceptions of gamifications on OSM and provided an initial insight into those perceptions. However, thematic analysis was limited to reveal reasons that cause contributors' different perceptions of gamifications on OSM with regard to their motivations. For instance, are different perceptions related to contributors' various motivations? In order to explain those perceptions in more detail,

it is necessary to relate contributors' perceptions emerging from thematic analysis of motivations extracted in factor analysis.

4. RESULTS

This chapter presents the outcomes of this study. A brief description of the collected data will be given first, and the findings of both analyses follow. The findings will be grouped into three sections. Firstly, the motivations derived from the factor analysis will be provided. The statistics from the factor analysis will be presented to justify the extraction and interpretation of the derived motivations, and data extracts in the interviews are also used to validate the motivation to contribute to OSM. Secondly, contributors' perceptions of current gamifications are presented along with data extracts from the transcripts. Thirdly, suggestions from interviewees for improving engagement on OSM are given.

4.1 Data

The online questionnaire had received 47 responses after being online for one and half months, however, only 35 of them were valid. Most of the responses were complete but there were 5 responses that contained empty answers. In order to produce less biased results, the 5 responses were excluded and 30 responses remained for subsequent factor analysis. There were totally 14 participants to the online questionnaire showing interests in interviews for discussing their experience with OSM and issues related to gamification. However, there were only 4 participants who replied to recruitment emails and had interviews with the researcher. The interviews were recorded and transcribed into 4 text files for subsequent thematic analysis.

4.2 Motivations to contribute to OSM

To identify motivations to contribute to OSM, factor analysis was first used to extract motivations from quantitative data collected from the online questionnaire. Factor analysis was used to distinguish major motivations from each other and provided statistics that facilitates the interpretation. The characteristics of the participants will be provided first, and the results of the factor analysis follows.

4.2.1 Characteristics of participants to the online questionnaire

The characteristics of participants collected in the online questionnaire are gender, age, country of residence, how long and how often they contribute to OSM. The characteristics helped understand the representativeness of the sample as well as related limitations.

Table 4.1 Gender, Age of Participants and Length of time and Frequency of their contribution to OSM

Characteristics	Categories				
Gender	Male		Female		Other
	29		0		0
	100%		0%		0%
Age	Under 18 yrs	18 – 30 yrs	31 – 45 yrs	45 – 60 yrs	Over 60 yrs
	0	12	11	5	1
	0%	41%	38%	17%	3%
How long have you been contributing to OSM?	One-time user	Under a half year	A half year to 1 years	1 to 3 years	Over 3 years
	0	1	1	8	19
	0%	3%	3%	28%	66%
How often do you contribute to OSM?	Several times a day	Several times a week	Several times a month	Several times a year	Not at all
	5	15	7	2	0
	17%	52%	24%	7%	0%

Table 4.1 provides the information on gender, age, and how long and how often participants contribute to OSM. From the table, it is noticed that participants who responded to questions concerning their characteristics are all male, and most of them are from 18 to 45 (23 out of 29). Most of the participants have contributed to OSM for more than 1 year at least several times a month. Regarding country of residence, most participants are from U.S.A and European countries except for 1 from Nigeria and 1 from Colombia. It is reasonable assuming that experienced contributors care more about various aspects of OSM and thus are more likely to subscribe to the email list for discussion of related issues, which explains why most of contributors have more than 1 year experience of contribution along with a frequency of several times a month. The communication language on *Talk* email list is English, which likely prevents contributors who are not comfortable in English from subscribing to the list and thus participating this study. This answers why most of participants are from U.S.A and European countries. Overall, most participants in this study can be characterized as experienced contributors from U.S.A and European countries.

4.2.2 Motivation identification in Factor Analysis

There are four main motivations emerging from the factor analysis: Self-need regarding community, Data Improvement, Monetary Award, and Altruism. These motivations describe what

participants perceive as important to them in OSM and thus motivate their contribution. The identification and interpretation of these four motivations using factor analysis took a step-by-step justification, and these steps will be described in detail in the following sections.

The original quantitative dataset on which factor analysis was conducted contains 20 variables, and there were 35 valid responses out of 47. However, due to empty answers, after listwise deletion, only 30 rows of 20 variables were left for factor analysis, and thus the response versus variable ratio is 1.5:1. As suggested earlier, it is necessary to examine the adequacy of a dataset that has a low ratio to determine whether the dataset can generate representative results. Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy is thus applied to examine the adequacy. KMO index for all 20 variables has a value of 0.444, which is much smaller than a recommended value 0.50 (Williams et al., 2010; Dziuban & Shirkey, 1974). According to Dziuban and Shirkey (1974), factor analysis requires prior judgements concerning which variables should be included, and the use of the measure of sampling adequacy is to assess the efficacy of the judgements. The smaller index had suggested that the inclusion of some used variables might not be appropriate, and remedial actions that involve excluding some variables should be explored to improve the index (IBM Support, n.d.). After an analysis on the correlation matrix of the 20 variables, the fifth variable ("I contribute to OSM because it is an alternative to other map platforms") was excluded since the variable was negatively correlated to almost all the other ones, and according to IBM Support (n.d.) that KMO index lower than 0.5 occurs when such variables are included. In addition, the sixteenth variable, which described contributors' agreements with that they contribute to OSM as part of a Mapathon ("I contribute to OSM because I enjoy participating in Mapathon"), was also excluded since the focus of the variable was specifically on the role that the Mapathon played in encouraging contribution. Another pair of KMO and Bartlett's Tests was conducted on the new dataset following the exclusion of the 5th and 16th variables (Table 4.2). The new KMO index had a value of 0.510, which was larger than the recommended 0.50 along with Bartlette's Test of Sphericity having a p-value of 0.000 ($p < 0.05$). It demonstrated the adequacy of the new dataset for factor analysis.

Table 4.2 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.510
Bartlett's Test of Sphericity	Approx. Chi-Square	268.309
	df	153
	Sig.	.000

PCA extracted 18 factors from the dataset. However, the number of factors to retain remains for determination. As suggested earlier in the previous chapter, scree test was used to determine the number of factors to retain in this study. The scree plot (Figure 4.1) placed the 18 extracted factors as connected points in a two-dimensional graph with x axis labelling factors and y axis indicating eigenvalues. As suggested in Chapter Three, scree test is to visually locate a break point, where the scree plot starts to flatten, and the number of points above the break point indicates the number of factors that should be retained (Costello & Osborne, 2005; Williams et al., 2010). Therefore, the number of factors to retain was determined as 4 since the scree plot of the 18 extracted factors started to flatten at 5th point. Table 4.3 shows the eigenvalue of each component (factor extracted by PCA) along with variance explained. The first 4 factors account for 64% of variance of the dataset suggesting that the 4 factors could represent most information contained in the dataset.

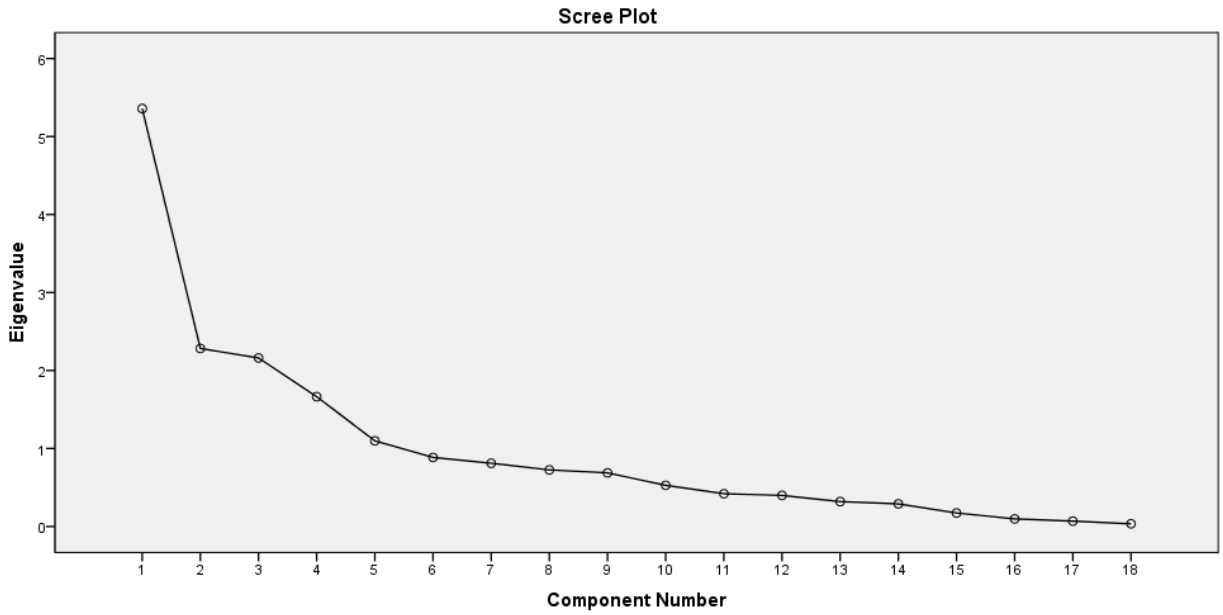

Figure 4.1 Screen Plot

Table 4.3 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.359	29.773	29.773	5.359	29.773	29.773
2	2.282	12.679	42.452	2.282	12.679	42.452
3	2.161	12.006	54.458	2.161	12.006	54.458
4	1.664	9.243	63.701	1.664	9.243	63.701
5	1.097	6.097	69.798			
6	.885	4.915	74.713			
7	.811	4.506	79.219			
8	.725	4.030	83.249			
9	.687	3.819	87.068			
10	.527	2.929	89.997			
11	.420	2.335	92.332			
12	.398	2.212	94.544			
13	.319	1.774	96.318			
14	.290	1.610	97.928			
15	.173	.961	98.889			
16	.097	.540	99.429			
17	.069	.382	99.811			
18	.034	.189	100.000			

Extracted factors were rotated using oblique rotation method – direct oblimin, and the produced factor pattern matrix was demonstrated in Table 4.4. The produced pattern matrix (Table 4.4) depicted the relationships between factors and variables through providing the loadings of the extracted factors on each variable, and the interpretation of factors was conducted based on the matrix. "A salient loading is one which is sufficiently high to assume that a relationship exists between the variable and the factor" (Gorsuch, 1974), thus the choice of a salient loading, is critical for interpreting factors. Previous research suggests a minimum between 0.30 and 0.40 for a factor being considered an attribute of variables (Zygmont & Smith, 2014; Schmitt & Sass, 2011). Moreover, the determination of a salient loading is also related to the sample size - smaller the sample size higher a salient loading required (Gorsuch, 1974). According to Williams et al. (2010) and Henson & Roberts (2006), at least two or three variables must load on a factor for a meaningful interpretation of the factor. In this study, the salient loading was set as 0.5 for both compensating the small sample size and having at least three variables loading on each factor. The interpretation identified four motivational constructs behind contributions to OSM, with each having at least three variables with loadings larger than 0.5 (highlighted in Table 4.4). 15 out of 18 variables were retained, while the other three variables failed to have salient loadings on any factors (Table 4.5). The table also provides Cronbach's Alpha which indicates the internal consistency of a factor. Despite the Alpha value of *Altruism* being slightly less than 0.6, the recommended threshold (Nunnally, 1967), the motivation was still considered important, as previous research suggested it as a significant motivation to create VGI. As for *Data Improvement*, the alpha of which is much smaller than 0.6, it was still suggested as an important motivation since the follow-up interviews had provided solid grounds for it.

Table 4.4 Pattern Matrix

	Component			
	1	2	3	4
v1	0.374	-0.482	0.421	0.198
v2	-0.428	-0.083	0.252	0.641
v3	-0.074	0.733	0.165	0.095
v4	0.133	0.145	0.279	0.643
v6	0.130	0.608	-0.072	-0.082
v7	-0.149	0.771	-0.020	-0.143
v8	0.235	0.596	0.190	0.308
v9	0.418	0.364	0.280	0.320
v10	-0.119	0.088	0.849	0.180
v11	0.131	-0.031	0.818	0.167
v12	0.099	0.051	0.686	-0.245
v13	0.821	-0.177	0.180	-0.080
v14	0.613	0.155	0.421	-0.065
v15	0.890	-0.001	0.092	-0.193
v17	0.430	0.241	-0.313	0.375
v18	0.708	0.075	-0.031	0.123
v19	0.743	-0.029	-0.191	0.347
v20	0.132	-0.117	-0.184	0.769

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

Table 4.5 Factor Loadings and Reliability Test for the Motivations

Factors	Variable	Corresponding Item	Factor Loadings	Cronbach's Alpha
Self-need regarding community	v13	I feel recognized by contributing to OSM.	0.821	0.842
	v14	OSM community is important for me to contribute to OSM.	0.613	
	v15	I enjoy interacting with other OSM participants.	0.89	
	v18	My OSM experiences have added richness to my life.	0.708	
	v19	OSM allows me to express my knowledge and expertise.	0.743	
Data Improvement	v3	I feel happy that others use my contribution to OSM.	0.733	0.406
	v6	I contribute to OSM because I saw many errors on it.	0.608	
	v7	I contribute to OSM because I find places I know are missing from the platform.	0.771	
	v8	I contribute to map data in the area I live because I want others to know the area.	0.596	
Monetary Award	v10	Part of my job responsibilities require me to contribute to OSM	0.849	0.722
	v11	I believe my contribution will help me in my career.	0.818	
	v12	I benefit from contributing to OSM financially.	0.686	
Altruism	v2	I contribute to OSM because the map data can be downloaded for free.	0.641	0.592
	v4	My contribution to OSM can help solve many social issues such as natural hazards or emergency responses.	0.643	
	v20	I believe in the OSM goal of creating of a free, open map of the world.	0.769	

The emergent four motivations were named as (1) *Self-need regarding community*; (2) *Data Improvement*; (3) *Monetary Award*; (4) *Altruism*. *Self-need regarding community* describes the importance of community in helping contributors to fulfil their need through the interactions with others. The interaction with other community members is meaningful to contributors, and their contribution allows them to express their knowledge and to feel recognised. *Data improvement* indicates that the willingness to improve data quality motivates the contribution, and contributors with these motivations expect others to notice or use their work. *Monetary Award* suggests that there is a number of participants contributing to OSM because they get monetary rewards from doing so. *Altruism* identifies contributors who aim to fulfil beliefs in the contribution helping the well-being of others.

4.2.3 Motivation identification in Interviews

T. The interviews aimed to investigate the efficacy of current gamification from the perspective whether the used game elements satisfy contributors' motivations. However, when interviewees talked about how they perceived gamification, they also related their perceptions to their motivations. From interviewees' words, most of the motivations that had been previously identified in the factor analysis were further validated especially for *Data Improvement,* which had a low Cronbach Alpha value. Furthermore, the details about how contributors' motivations were captured through the use of corresponding game elements were revealed.

4.2.3.1 Social-need regarding community

Social-need regarding community motivation was noticed when interviewees expressed their joy in receiving appreciation of their work, feeling motivated by the positive reinforcement. Simple positive feedbacks from others made contributors feel themselves recognised and their work valued. The following data extracts imply this motivation:

> If someone validates my work and sends me a message to the tasking manager saying "Great job, thanks for contribution". You know, I found that very motivating. I wish people do more that, try to do that (Participant C, 2016).

> If you actually go down to and contribute, then you have people in Lesotho who are twittering at you saying "Hey, great job. Thank you for helping us mapping out our country." So there is a level of feedback there. That's wonderful (Participant A, 2016).

4.2.3.2 Data Improvement

Data Improvement motivation was noticeable in the words of interviewees when they described how they contributed to OSM, such as correcting or creating geographic data. The following data extracts indicate this motivation:

> I will pull up a map anywhere in the world and realised, oh gosh these rivers intersect these roads, nobody puts any bridges. And then I will also have to spend next three day and nights adding bridges (Participant A, 2016).
>
> I get satisfaction out of improving data, updating, you know, making an area or town. Take a town, you know small towns. I especially like working on small towns because you can see the result of your work a lot more easily because you know a lot of small towns in the United States have not been mapped very much by anybody (Participant D, 2016).

The interviewees' descriptions also suggested most of them had strong interests in geography, and such strong interests may be initial reasons for them to check out OSM and start contribution. Moreover, it was noticed that all of the interviewees had previously worked on something related to GIS, and it was their GIS related experience that first got them into OSM.

4.2.3.3 Altruism

Altruism was identified as one of the main motivations on OSM in previous research (Budhathoki & Haythornthwaite, 2013; Coleman et al., 2009), and the interviewees also recognised its important role in motivating contribution. Interviewees coincidentally identified the increasing impacts of Humanitarian OSM team (HOT) in motivating contribution and recognised that a large portion of contributors was drawn to OSM as it provided them opportunities to help other people with humanitarian issues such as responses to natural disasters. The increasing impacts of HOT on drawing contributors have implied the significance of Altruism on OSM, and the following data extracts outline that:

> I think the humanitarian aspect has been fantastic, because that has gotten people in that wouldn't be drawn otherwise for just be mapping sake. There is some, you know, geography nerds like myself who will just map because "Oh, maps are awesome". But once you can put the hook up about you are helping people humanitarian, then that brings in a whole other group of people (Participant A, 2016).
>
> So that's successful, um, again and humanitarian aspect often draws people in. They are like "Oh I want to help the world, but I don't really know mapping, maybe I'll show up to this help the world event" (Participant A, 2016).

> Yes, I kind of look at the humanitarian map is a kind of give-way drug, you know get people introduced to OpenStreetMap. And actually, I have heard somebody say "Wow, when I first learned about OpenStreetMap, you know, mapping about your neighbourhood, I wasn't really too interested, but this is meaningful to me. This is something I feel worthwhile mapping to help people at the Red Cross, help people wherever disadvantageous, very vulnerable" (Participant C, 2016).

The interviews validated the motivations extracted from factor analysis. Self-need regarding community, Data Improvement, and Altruism were identified in the interviews while Monetary Award was not seen. The identifications provided strong grounds for keeping both Data Improvement and Altruism that were previously questioned in statistical reliability tests. Monetary Award was not noticed in the interviews, which led to questions about why it happened. The missing could be due to the small number and characteristics of the participating interviewees.

In addition to validation of motivations extracted from the factor analysis, the interviews also provided insights into how contributors' motivations were captured by various aspects of OSM. Receiving others' appreciation seem to capture contributors' self-need regarding community. Seeing the inaccuracy or absence of geographic data on OSM seems to trigger contributors who have Data Improvement motivation to consistently create geographic information on OSM. Contributors who have altruism motivation resonate with the opportunities provided by OSM to help others with humanitarian issues. These insights are important for understanding the relationship between various aspects of OSM and contributors' motivations, and such understanding will help engage contributors effectively.

4.3 Perception of current gamifications on OSM

The application of gamification on OSM aims to engage more contributors by making the contribution process attractive and as a result, improve the data quality on OSM. Previous research has suggested that effective gamification practices should consider the interactions between applied game elements and participants in the context on whether the game elements capture contributors' motivations (Deterding, 2011; Jung et al., 2010). To learn whether those game elements capture contributors' motivations, how contributors perceive those game elements is important to know, thus thematic analysis is used to learn contributors' perceptions from the interview.

The thematic analysis of the interview transcripts suggested both positive and negative attitudes. Most of the interviewees held negative attitudes towards existing gamifications on OSM and perceived the used game elements as not effective on either attracting more contributors or improving data quality. Negative attitudes were also expressed towards cheating behaviours triggered by gamifications. Specifically, interviewees noticed other users used automation techniques, which they were not supposed to use, in order to win a contest. Some interviewees noted positive aspects of gamifications. A competition atmosphere fostered by the used game elements was regarded as beneficial to generate more contributions. Because of the competition and observed cheating behaviours, contributors started to self-police others' works to ensure the integrity of competitions, which further assure data quality.

4.3.1 Negative perception

Most interviewees hold negative attitudes toward existing gamifications on OSM as they perceived them not helpful in motivating their contributions. Existing gamifications on OSM are various, however, most interviewees seem to have only experienced gamifications using simple game elements such as statistics and leaderboard, and their perceptions were through experiences with those game elements. Providing participants with statistics about their activities is widely used in gamification practices, and an example on OSM is "How do you contribute to OSM", which provides statistics on individual OSM user's contribution with regard to which geographic area their contribution is made to, the number of edits, and so forth. The use of leaderboard aims to engage participants in the applied system by creating competition environment among them, and an example on OSM is the one in *Missing Map* that ranks contributors according to their contribution with regard to a total number of edits or number of edits on a specific type of ground features. The interviews had shown that contributors acknowledged the existence of statistics and leaderboard, while most of the interviewees explicitly indicated they were not motivated by those elements since they did not compare their contribution to others' regarding numbers or they were not contributing for the increase of the numbers. These feelings were expressed by various interviewees when they were asked about whether they feel motivated by the current gamifications:

> Yeah, I'm not really. There is a little bit motivation in things like that, but I don't think it's the, at least not for me, I don't think it's a main motivating factor (Participant C, 2016).
>
> OK, alright. I don't think people contribute to OSM; I don't think that people care gamification too much because they are not doing it earn points. I mean it's interesting in

> a sort, passing interests. I don't think that's why people contribute. It would be a by-product to the contribution rather than the reason they do (Participant B, 2016).

The negative attitude towards existing gamification also came from contributors' observations on cheating behaviours triggered by gamification-created competition environment. One interviewee expressed his frustration on the behaviours by saying:

> I did participate in a contest once, where we were competing with other people, but that I wasn't very happy with the way that turned out, because some people were cheating using scripts and other tools to generate more data in less time, and they weren't supposed to do that, but they got away with it. So, that's kind of disappointing (Participant D, 2016).

It is important to notice that this interviewee's frustration was on others' violations of the competition rules. However, another interviewee's concerns on the cheating behaviours were not on the violations of the competition rules, but the useless geographic data that the behaviours produced. The interviewee observed other contributors created useless geographic data to win a context:

> Second challenge I think they use MapRoulette or something, force people into a model. The first one was just we will measure how many edits you make at all to the United States on highway or something. And of course there was at least one user who just started making a bunch of useless changes, just to count edits. Um, they, specifically, and because they posted their leaderboard on a daily basis. You could see who the user was, users' work that was ranking up the most stats. You could use the existing OSM tools to say "are they really mapping well?" or "they're just trying win this contest." So, I did the analysis and looked what this leading editor was doing, and they were chopping up the streets of in every US town for the ones that were inside and outside the town. And the ones that were inside the town, they were adding a tag that said this street is in this town, which is kind of useless, it is not technically wrong, it's just useless. (Participant A, 2016)

4.3.2 Positive perception

Though negative attitudes were held among most interviewees, there was still positive feelings about game elements. There was one interviewee identifying those statistics and leaderboard as motivational factors that the game elements create feedback loops and competition environment motivating consistent contribution. The interviewee described his feelings as follows:

> I discovered things like the "how do you contribute" page that, you know, shows you exactly how much you mapped and where. And that started the feedback loop that like I will map and see my numbers go up and then I map some more and see my numbers go up, and that I started to feel like oh, and then I get pointed to my rank and say other mappers "Hey I'm really active", and they'll be like "Yes, cool you are" (Participant A, 2016).

Self-policing was also identified by interviewees as a positive action introduced by gamification. Contributors will self-police the quality of contribution when there is competition between them. It is intuitive for a competitive contributor to check out someone else's contribution when he or she sees this contributor ranking before him or her on a leaderboard. The activity was demonstrated in the previous data extract in which interviewee described how he found someone was making useless contributions. Some of the self-policing actions also stem from contributors' feelings about the ownership of data created by them. This kind of feelings induces them to check on the data previously edited or created by them when someone else makes changes to it. The following data extract outlines this:

> I went to, did something in another area, and the person does a lot of activities in that area got in touch with me, said: "what're you doing?" I mean, "you haven't done this right at all", and I actually made a mistake. Um, so I got not shout at that, but I got picked up on that. This is about I think I wouldn't say so it's total self-policing but there is an element of self-policing in it. Because, it's more about the ownership (Participant B, 2016).

4.4 Engagement Suggestions

The interviews were held to understand contributors' perceptions of existing gamification on OSM. Gamification on OSM is expected to make contributors feel motivated and get them engaged, but the thematic analysis suggested that current gamifications seemed not to have significant impacts on motivating contribution and might even be a net negative for data quality. Given how little impact game elements had on encouraging motivation, interviewees also provided some interesting suggestions on how to engage more contributors and how to collect more geographic data. The suggestions were given by interviewees based on their experiences with OSM and related applications on three perspectives: passive contribution, positive feedback, and humanitarian aspect. These three perspectives will be elaborated in the following sections.

4.4.1 Passive contribution

VGI can be created by contributors with and without their active engagement in the creation process, and thus can be classified into two types: active and passive (Haklay, 2013). An active contribution is that people consciously create geographic information as in the case of OSM where ground features are digitised by contributors visually interpreting the aerial images. A passive contribution is the geographic information gathered when people perform activities without their active engagement in the creation process, for instance, people volunteers to be tracked by a GPS-

enabled mobile device to record their walking activities (Haklay, 2013). OSM is such a project on which most contribution is active as suggested earlier, however, several mobile applications have introduced passive contribution to OSM. The geographic information is collected by those applications from their users and shared with OSM. A few interviewees identified that the use of those mobile applications would be more effective in collecting particular types of geographic information. One interviewee illustrated Strava as an example:

> Strava is a user of OpenStreetMap and if you're a user of Strava, if you have an update out, what they do is they collect and store all of the bike routes and running routes you have done. They strip off your name, any personal identification information, and they remove the first few hundred meters, so in case of start from home, people can't see that. And they make that data available to OpenStreetMap, so this is great way finding trials that are missing, even roads are missing in OpenStreetMap (Participant C, 2016).

The trajectories shared from Strava can assist contributors on OSM to identify trails and streets that are not able to be visually interpreted through satellite imagery or otherwise, which helps the improvement of the locational accuracy of those ground features. The case of Strava demonstrates that the integration of passive contribution from other mobile applications is beneficial to the improvement of data quality on OSM. The interviewee also pointed out that the contribution process should be designed to be more passive:

> I think it's a potential there. I don't know exactly that will work. We can come up our ways, or people can just kind of, has to be very easy, very passive there, they might have, you can't ask them to do a lot of work (Participant C, 2016).

4.4.2 Positive Feedback

Interviewees perceived statistics and leaderboards as not helpful on motivating their contribution, however, they coincidently indicated others' positive feedback on their works as important motivating factors for them. The interviewees suggested that feedback on their works as simple as "Great Job!" could make them feel motivated to contribute more. The following data extract best illustrates the motivational effect of positive feedbacks:

> And someone else goes in there, and validates that work. If someone validates my work and sends me a message to the tasking manager saying "Great job, thanks for contribution". You know, I found that very motivating. I wish people do more that, try to do that (Participant C, 2016).

Interviewees also recognised the importance of communication channel by which people can easily express and receive appreciations. One interviewee illustrated the active Twitter community

in the Map of Lesotho project suggesting that Twitter helps the positive feedback on others' work to be easily expressed and received. The following data extract outlines this:

> Um, because there is an active Twitter community there, you actually, we actually learned the people involved, and there is very public recognition to say, you know, you by name, great job you did there (Participant A, 2016).

One interviewee also pointed out the improvement on making contributors receive positive feedback immediately could get contributors consistently involved and thus contribute more:

> And I think that can improve the tasking manager because currently, you have to log in the tasking manager to see your messages, they don't get forward to your email. So if you are not, you are not in the tasking manager, let's say you did a bunch of contribution, now you're busy with work and the rest of your life, you are gonna miss those messages. You will eventually see them, but you do not get that immediate or near immediate feedback (Participant C, 2016).

The motivational effect of positive feedback is reasonable considering contributors' motivations. Three motivations identified in factor analysis – self-need regarding community, data improvement, altruism – are all captured when contributors receive others' appreciations on their works. Self-need regarding community is captured that their contribution is appreciated by others and they feel recognised. Data Improvement is captured that their contribution to improvement is noticed. Altruism is captured that they feel their contribution help others and thus get appreciated.

4.4.3 Humanitarian Aspect

Altruism is a critical motivating factor on OSM, and it is demonstrated in contributors' active engagement in humanitarian projects on OSM. As suggested earlier, humanitarian projects attract contributors who are not interested in mapping or creating geographic data but in helping other people. The amount of contributors attracted by humanitarian aspects is significant, which suggests the potential of the aspect for engaging more contributors to OSM. Martin Dittus (2016) conducted an analysis of the impacts of humanitarian projects on building large-scale crowdsourcing community, and the analysis had demonstrated that the cumulative number of HOT contributors rose substantially whenever there was a terrible natural disaster. As suggested by interviewees, improvements on HOT tasking manager should be made to better take advantage of the significant impact of humanitarian aspects on motivating contribution. Improvements such as letting contributors receive appreciations from others immediately or know that their work helps the local people will support contributors' Altruism motivation, thus inducing engagement.

4.5 Summary of results

This chapter has presented the findings of this study, through analyses of quantitative data collected by the online questionnaire and qualitative data collected by interviews. These sources of data have produced information about the main motivations on OSM and contributors' perceptions of current gamifications on OSM. The four main motivations have been identified: self-need regarding community, data improvement, monetary award, and altruism. Both positive and negative perceptions of current gamifications on OSM were noticed along with suggestions for engagement provided. Most of the interviewees perceived current gamifications on OSM – mainly statistics and leaderboards - as not helpful in motivating their contribution or engaging contributors since the applied gamifications do not capture contributors' motivations. The suggestions for engagement have indicated that contribution can be motivated through providing positive feedback on contributors' works as well as promoting the humanitarian aspect of OSM. In the other hand, these suggestions also demonstrate the importance of capturing contributors' motivations when engaging them. The information on characteristics of participants to the study helps understand how derived contributors' motivations and perceptions are related to these characteristics as well as the limitations of the findings.

5. DISCUSSION

This chapter will expand the findings presented Chapter Four. First, the motivations identified through factor analysis will be discussed in relation to those suggested in previous research. Second, the perception of game elements will be analysed from the perspective of motivational affordances in relation to contributor's motivations. Lastly, engagement approaches will be discussed in term of how they will engage contributors in creating geographic information to improve OSM and VGI projects. Directions for future research will follow, as well as a discussion summary.

5.1 Motivations to contribute to OSM

Self-need regarding community, data improvement, monetary award, and altruism emerged from the online survey through factor analysis. These motivations are believed to explain why contributors create geographic information on OSM voluntarily. However, the motivations identified in this study are not exactly those suggested in previous research (Coleman et al., 2009; Budhathoki et al., 2010; Budhathoki & Hayhornthwaite, 2013), and both similarities and differences exist.

Monetary award was identified in this study as well as previous research. It suggests though OSM does not incentivise contributors with money there are still opportunities for potential monetary rewards that motivates contribution to OSM. The empirical study by Budhathoki & Haythornthwaite (2013) also extracted monetary award as a factor with the highest eigenvalue, which suggested the prominence of the motivation on OSM. With a company such as Mapbox, which uses OSM to provide geospatial services to its customers and also hires people working on OSM dataset, it is reasonable that some contributors create geographic information expecting monetary rewards such as salary or potential career advancement. However, monetary award was not recognised in the interviews, and this may be due to that there was only 4 interviewees and none of them contribute geographic information expecting monetary rewards.

Altruism motivation suggests that many contributors create VGI on OSM for the benefit of others without expecting gain or improvement of their personal situation (Coleman et al., 2009). The goal of OSM is to create a free and open map of the world, and contributors are drawn to this goal of contributing free geographic information for others' use. Therefore, it is not surprising that both

this study and previous research (Coleman et al., 2009; Budhathoki et al., 2010; Budhathoki & Hayhornthwaite, 2013) identified Altruism as an important motivation behind VGI contribution on OSM. Furthermore, OSM has played a critical role in response to natural disasters and hazards in recent years. Participation of a large number of active contributors in projects organised by Humanitarian OSM team (HOT) was noted in conjunction with many natural disasters in the past few years (Dittus, 2016). Contributors voluntarily worked together to map areas impacted by natural disaster and hazards aiming to assist governments and organisations in responding to the event. This active participation in HOT projects surely demonstrates that altruism is an important motivation.

Self-need regarding community denotes the important role that OSM community plays in motivating contribution. OSM community provides its contributors opportunities for collaborating and discussing with others. Through collaboration and discussion contributors perceive their contribution as part of a collective effort, which further encourages contribution (Kuznetsov, 2006; Benkler & Nissenbaum, 2006) Furthermore, positive feedbacks from the community can make them feel recognised and thus motivate more contribution. The studies of motivations in online communities that rely on collaborative and voluntary contributions like OSM provide grounds for this motivation. Lerner & Tirole (2002) suggested that contributors to open source software were incentivised by ego gratification, and such ego gratification is satisfied largely by the peer recognition through interaction within community (Budhathoki et al., 2010). Similarly, Kuznetsov (2006) found that Wikipedia contributors were driven by perceived common values and respects through interacting with other community members. Consolidating those research in open source software, Wikipedia, and other user contribution systems, Coleman et al. (2009) suggested social reward as one of the important motivations for creating VGI. The motivation was explained as "by being part of a larger network or virtual community where – through collaboration, discussion and development of the resource – contributor acquire '…a sense of common purpose and belonging that unites them into one community' and encourages further sharing" (Kuznetsov, 2006, p.4). The identification of self-need regarding community motivation echoes those previous findings and further implies that interaction within OSM community motivates contribution.

Data improvement is a unique motivation identified in this study but not in previous research. The motivation recognises that contributors create VGI aiming to improve data on OSM. Though

previous research did not identify this motivation, related motivations were proposed. Budhathoki & Haythornthwaite (2013) identified self-efficacy regarding local knowledge as an important motivation to contribute VGI, which suggested that contributors intend to map places missing from OSM and correct errors in their local area. In this study, it was noticed that contributors had eyes beyond their local area aiming to improve data on OSM in general, which suggests that data improvement should be an important motivation to contribute to OSM. Furthermore, data improvement may be a unique motivation that exists for motivating active contribution. As we suggested earlier, OSM is an active contribution project on which contributors consciously engage in creating geographic information. The goal of OSM is to provide a free world map, and it definitely relies on a huge amount accurate geographic data. The devoted contributors should dedicate efforts to contribute and improve geographic data on the project to achieve the goal. Thus, data improvement surely makes a major motivation to contribute to OSM. However, this motivation may not exist for passive contribution as passive contributors create geographic data without active engagement.

This study adopted similar statistical technique, factor analysis, identifying motivations to contribute VGI as Budhathoki & Hayhornthwaite (2013) did except that an oblique rotation instead of an orthogonal rotation was applied in this study. The motivations identified in the work by Budhathoki & Hayhornthwaite (2013) are independent to each other due to the applied orthogonal rotation approach. However, two of the extracted motivations from this previous study - learning and personal promotion - seem to violate the assumption of independence as the goal of learning is related to achieve personal promotion, which suggests the infeasibility of the orthogonal rotation approach. As mentioned earlier in Chapter Three, the dependence of motivations should be assumed unless previous knowledge about the independence is acquired. Therefore, the factor analysis applied in this study should extract motivations that are more practical than the previous study.

5.2 Perception of game elements

The primary goal of gamification on OSM is to engage contributors in creating geographic information as well as assuring data quality. Current gamification instances on OSM focus on creating feedbacks and fostering a competition environment by using game elements such as statistics and leaderboards. However, according to the interviews, most of the contributors perceive

the game elements as not effective in encouraging them to contribute to OSM and do not really care about these elements. The perceptions from the interviewees indicate that the motivational affordance of applied game elements is not perceived by contributors as expected. As suggested earlier in Chapter Two, low motivational affordances may result from transferring game elements without consideration of the motivations in the situated context. The reasons for the negative perception of game elements with regard to motivational affordances will be elaborated in this section.

The statistics provide contributors feedbacks on their contribution to OSM. For instance, *How did you contribute to OpenStreetMap* allows contributors to check on their activities in various categories such as geographic region of contribution, and numbers, graphical charts, and maps are displayed to provide a comprehensive view of one's contribution to OSM. However, as suggested by most contributors, these feedbacks have little impacts on encouraging them to contribute to OSM. This may be due to two reasons. First, the use of feedback is to allow contributors ".. to evaluate how close current behaviour is in relation to a set benchmark" (Weiser, et al., 2015, p.5), thus merely providing statistics without benchmarks is not able to engage contributors. The absence of benchmarks makes it difficult for contributors to examine their progress or to feel a sense of achievement. Second, the feedbacks provided by the statistics mean little to contributors with regard to their motivations. Seeing the increase of the metrics about their contribution does not satisfy the four motivations identified. Self-need regarding community is not satisfied as there is no interaction with other fellow contributors involved in seeing the statistics; Data improvement is partially satisfied as the increased statistics does demonstrate more data contributed while there is no clear sign showing the quality improvement; Monetary award is also not satisfied as no monetary reward is linked to the increase of the statistics; Altruism is not satisfied since the statistics do not indicate that someone benefits from the contribution. Thus, it is reasonable for the motivational affordance of statistics being low and not perceived by the contributors and in turn the element being regarded as not motivating.

The use of leaderboards aims to foster competition environment promoting contributors' comparison behaviours in order to engage them. For instance, *Missing Maps* provides leaderboards that rank contributors with regard to various categories such as total edits and building edits, and it offers contributors some extent of autonomy choosing preferred type of contribution for

competition. The satisfaction of competence, "a need for challenge and feelings of effectance" according to Ryan et al. (2006), has positive influence on increasing engagement, especially for those who need achievement (Weiser et al., 2015), and thus targeting at needs for achievement is a common pattern in gamification (Dixon, 2011). However, except one interviewee explicitly expressed his feeling of achievement from competing with others and seeing his rank climbing up, most of the interviewees did not perceive leaderboards as motivating. This may be due to that the contributors on OSM do not acquire achievements from competition. For contributors with self-need regarding community motivation, recognition from other contributors and within the community may mean achievement; for those with altruism motivation, achievement is more about that geographic data contributed is useful to others. In general, competition may not be wanted for most of the contributors as they do not regard contributing more as achievement, based on their motivation profile. Thus, using a leaderboard is not as helpful in motivating contribution.

Unexpected adverse phenomena such as useless geographic information and cheating behaviours worsen contributors' perception of game elements. It was noticed by interviewees that competition led to contributors creating useless geographic data and cheating in order to win contests. These useless contributions and cheating behaviours have demonstrated that competition can be problematic in a context where competition is not wanted (Weiser et al., 2015), and these issues should be concerned as they depart from the intention of fostering competition environment. Moreover, as suggested by interviewees, supervision strategies should be implemented in response to potential useless contribution if competition is promoted, otherwise, game elements such as leaderboard that uses competition mechanism can demotivate contribution.

Feedbacks and competition mechanics are commonly used for gamification in many contexts (Weiser et al., 2015; Hamari et al., 2014), and they are implemented through statistics and leaderboards in OSM. However, contributors' perceptions have suggested that the used game elements are not effective in motivating contribution. The motivational affordances of both game elements are not perceived by most contributors, and which prevents contributors from taking actions on the elements (Zhang, 2008). In accordance with contributors' motivations, the reasons why motivational affordance is not perceived can be explained from the perspective that the game elements are not able to afford contributors' motivations, which further leads to contributors' perception of elements as not effective in motivating contribution.

The perception of game elements as not effective further demonstrates that simple transfer of game elements in non-gaming contexts may not have similar motivational affordances (Deterding, 2011), and also indicates that the understanding of motivations of users is important for effective gamification design. The knowledge on player type such as Bartle's type (1996) provides insights into game designs considering different motivations for game play, and this knowledge is borrowed for gamification design (Kim, 2012; Martella et al., 2015) expecting that game elements would have similar impacts on engagement in non-gaming contexts. However, as pointed out by Dixon (2011, p.4), "although some aspects can be extrapolated from one domain to another, not all research about digital games can be applied directly to the gamification of other applications". Current gamification on OSM is a good example of this. In order to better extrapolate the knowledge from games to a non-gaming context, it is necessary to investigate the factors that can influence the applicability and efficacy of gamification in the non-gaming context. Motivation should be one of the factors that need designers' concerns since they influence whether motivational affordance of used game elements can be perceived by users and which thus affects engagement outcomes (Zhang, 2008; Jung, 2010).

5.3 Towards effective engagement on OSM

Contributors' perceptions of currently applied game elements have suggested that current gamification instances on OSM are not effective in engaging contributors since contributors' motivations are not taken into consideration in the design process. However, a couple of interesting suggestions have been given by the interviewees on gamification for OSM as well as non-gamifying approaches for engagement based on their experience with OSM.

5.3.1 More effective gamification

VGI can be created by contributors either consciously or not, and thus contribution can be further classified into active and passive types (Haklay, 2013). Some interviewees suggested that effective engagement should make the contribution process as passive as generating running and biking trajectories in Strava. However, it is important to acknowledge that passive contribution limits the types of geographic information contributed. For instance, as in Strava, only location information collected by GPS can be contributed. Geographic information such as a textual description of a place still requires active contribution (Haklay, 2013).

As suggested earlier, currently applied game elements for active contribution have little impact on engaging a contributor. Game elements like statistics and leaderboards implement simple and intuitive mechanisms, and because of this they are easily and commonly applied in various contexts. However, there are more advanced game elements like storytelling and experience which immerse players significantly but have not been explored for gamification on OSM. Recent discussions on vandalism caused by Pokemon Go players may provide insights into the motivating impact of the more advanced game elements. According to a recent post on OSM *Talk* email list (Murray, 2016), it was noticed that Pokemon Go players contributed to OSM in order to increase spawn activities in Pokemon Go. The theory players proposed is that tagging line features with tag "highway=footway" will increase Pokemon spawn activities, thus players were adding footways on OSM taking advantage of this mechanism. The noticed behaviours by Pokemon Go players have provided an example in which rich experience and stories implemented through advanced game elements are helpful to attract contribution. Furthermore, the example of Pokemon Go also implies the possibility of using augmented reality games in engaging contributors to create geographic information. The potential of augmented reality game in geographic information collection is also supported by the massive player base of Ingress, a location-based augmented reality game, and Microsoft patents on the use of augmented reality game in geographic information collection (Etter et al, 2012; Mahajan & Ocko, 2013).

The case of Pokemon Go also pointed out that gameful experience should be targeted for gamification. Huotari & Hamari (2012) highlighted that the goal of gamification was to give rise to gameful experience since it was the gameful experience that resulted in engagement. It is important to emphasise that gameful experience is a subjective perception of users, thus game elements will create a gameful experience for one user but do not do so for another user (Huotari & Hamari, 2012). Players of Pokemon Go contribute to OSM out of the fun from catching more Pokemons, and catching more Pokemons is the gameful experience that really attracts them to OSM. Current gamification on OSM simply applies game elements without taking contributors' motivations into consideration may not create gameful experience that can be perceived by users, thus it is definitely more possible for the perceptions of the used game elements as not effective.

Future gamification design in VGI context should take inspiration from the case of Pokemon Go players, and aims to provide contributors gameful experience. As suggested by interviewees, new

contributors cannot be asked to do too much, and the creation process should be made easy. The gameful experience can help new contributors get interested in creating VGI without feeling complicated about the creation process. As for more experienced and active contributors, gameful experience can assist to direct them to contribute to particular area, for instance, under-mapped area or to work on particular issues such as validation. The case of vandalism caused by Pokemon Go players has demonstrated the potential of using gamification to direct contributors to work on particular types of geographic data. Gamification designers should explore appropriate game elements from the two perspectives.

5.3.2 Self-policing and Positive Feedback

The adverse consequence caused by competition environment, useless contribution and cheating, induces self-policing behaviour, which can contribute to quality assurance and engagement. The adverse consequence makes contributors pay more attention to others' works, which should lead to exposure of errors to more eyes and thus increase quality. Self-policing behaviours do not only result from the adverse consequence of competition but also a sense of ownership. Though contributors create geographic information for others' free use, they still have a sense of ownership of the geographic information created by themselves. Contributors concern changes on the geographic information created by them wondering why others make changes and worrying whether others may "mess up" their works. Moreover, this sense of ownership also goes beyond the geographic information created by contributors themselves and turn into concerns on the area that contributors frequently works on, especially those that they have local knowledge about. Contributors tend to verify changes on geographic data that they are familiar with in reality, even though the geographic data is not previously created or updated by them. If the sense of ownership is taken advantage of, contributors may be better engaged to check on the data created by them and area where they regularly contribute, which should help assure data quality. For instance, designs that notify contributors about changes on geographic data created by them or in areas where they regularly contribute should help engage them as well improve data quality.

It was noticed that contributors perceive others' positive feedback as more motivated than game elements. Interviewees expressed even words as simple as "Thank you" were more helpful in motivating them to contribute more. This may result from the fact that others' positive feedbacks satisfy contributors' motivations. Positive feedbacks make contributors learn that their

contribution is appreciated and thus feel recognised. However, there are limited functions or channels provided on OSM through which contributors can make positive feedbacks on others works. Hamari & Koivisto (2015) suggested adding features such as "liking" enable users to give feedback on others' activities resulting in recognition and capturing motivations related to user community toward the use of the system. Furthermore, features such as sharing functions should also be added allowing users to communicate or make visible their activities for accepting social influence such as positive feedbacks from others (Hamari & Koivisto, 2015). These features should further facilitate social interactions within the community and help introduce new contributors to the community. OSM has discussion forums, email lists, and functions through which contributors can connect each other, and these surely facilitate social interactions. However, as pointed out by one interviewee, more comfortable and user-friendly features should be added to promote socialisation perspective of OSM.

5.3.3 Humanitarian aspect

In recent years, OSM has demonstrated its potential in helping with humanitarian issues such as natural disasters. Humanitarian projects administered by Humanitarian OSM team (HOT) provide geographic information for people and organisations in response to various natural disasters. According to Dittus (2016), humanitarian aspect of OSM has attracted many new contributors to OSM, and there were peaks of active contribution activities every time a highly publicised event such as when the 2015 Nepal earthquake occurred. For both old contributors and new contributors, this humanitarian aspect offers them opportunities to satisfy their altruism motivation to help other people and to acknowledge that their work is beneficial to others.

A Mapathon, an event in which contributors gather and contribute to OSM, provides an important opportunity promoting the humanitarian aspect of OSM and attracting new contributors, as mentioned by Participant A and C (2016). This type of event can introduce newcomers about OSM and its humanitarian aspects acknowledging them how their contribution is beneficial to other people on the other side of the planet. Furthermore, as suggested both by Dittus (2016) and Participant C (2016), people like to know that their contribution will have a real impact, which makes experience from a person who has physically been to the local area and stories about how contributions to OSM helps local people motivating factors.

5.4 Limitations

The data for factor analysis was collected through online surveys, and it was self-reported by respondents. The use of self-reported data may influence the results since respondents are most presumably active in contributing to OSM and eager to participate in related activities. The information about how long and how often participants to the survey contribute to OSM further confirmed that all participants were experienced and active contributors. Therefore, the extracted motivations possibly represent motivations of active contributors and disregard those of less active contributors. Furthermore, the sample size for factor analysis is relatively small, which leads to a small ratio of responses and items. The ratio of responses and items in the dataset is 35/18, slightly less than 2:1. Previous research had a debate on the critical role of the ratio playing in the reliability of factor analysis results. Various minimum ratios ranging from 3:1 to 20:1 were recommended by previous research (Zygmont & Smith, 2014; Pett et al., 2013; Costello & Osborne, 2005; Gorsuch, 1983) while Hogarty et al. (2005) used empirical studies suggesting no minimum ratio required. However, the ratio is definitely smaller than most recommended minimum values, this issue should be addressed in the future study using a large sample size.

There were 14 contributors who had shown their interests in participating in interviews, however, only 4 actually participated. As suggested earlier, the small number of participants may be the reason why monetary award motivation was not identified in interviews. The small number may also result in the perceptions biased and the findings less representative. The interviewees are most presumably active in contributing to OSM and eager to participate as they were selected based on their willingness. Thus, the results from thematic analysis reflect mostly active contributors' attitudes toward gamification on OSM and may not truly indicate the attitudes of less active contributors.

The participants to the survey were recruited through OSM *Talk* email list, and interviewees were then recruited from those participants. The *Talk* email list is designated for discussion of general issues related to OSM, and English is the communication language on it. However, OSM also has many email lists designated for discussion of issues in specific countries or aspects. Due to limited resources and language barrier, this study did not try to recruit participants through other email lists. This led to the fact that most participants were from U.S.A and European countries, which is supported by the characteristics information. Therefore, the findings from both factor analysis and

thematic analysis may be biased since contributors who are from countries other than U.S.A and European countries or not comfortable speaking English did not provide opinions on the issues discussed in this study.

The small sample size and the recruitment channel both contribute to potential biases in the results. As suggested earlier, less active and new contributors are missing from this study, thus the results may not imply exactly how they will be motivated to contribute to OSM and perceive the used game elements. However, this can be addressed in future studies in which more representative samples are used. For instance, same questionnaire can be distributed to events like Mapathon, which consists of a number of new contributors, to learn their motivations. The knowledge about motivations of less active and new contributors and their attitudes toward gamification can be further added to this study to provide a more comprehensive insight into the issues. It can be estimated that Altruism will definitely be an important motivation for a number of new contributors. As suggested by interviews, events like Mapathon get new contributors know the opportunity through OSM to help disadvantageous and vulnerable people, and makes those who are previously not interested in mapping really start to contribute a lot. Less and new contributors may be motivated by various motivations, but they are waiting to be identified in future studies. Furthermore, causes that lead to less active involvement in contributing to OSM may also emerge in future studies and responding engagement suggestions and design can be explored.

5.5 Discussion summary

The extracted factors through factor analysis have outlined four major motivations to contribute to OSM. The findings of these motivations further verify those identified by the previous study and also provide new types of motivations. Furthermore, the findings of motivations provide reference knowledge for the discussion on contributors' perceptions of game elements. Contributors' perceptions of game elements are discussed in accordance with motivations identified. The perception of game elements held by most contributors as not helpful is due to that the game elements are not able to afford contributors' motivations. Simple transfer of the knowledge in games and game elements to another non-gaming domain may not lead to similar motivational affordance and engagement outcome (Deterding, 2011). The motivational affordance of the used game elements is perceived as low since contributors' motivations make them care little about neither increase of the metrics about their contribution nor competition with other contributors,

therefore the game elements have little impacts on engaging contribution. Though current gamification seems not to capture contributors' motivations and have little impact on increasing engagement, strategies regarding engagement can be developed from the interviews. The example of Pokemon Go has demonstrated the potential of advanced game elements in motivating contribution, and augmented reality games may also play important roles in gamification in VGI context in the future. It also pointed out that gameful experience rather than methods or mechanics should be emphasized for gamification design. Self-policing activities and contributors' preference towards others' positive feedbacks should be taken advantage of in order to engage consistent contribution as well as to assure data quality. Positive feedback makes contributors feel recognised and thus afford their motivation related to the community. The role of OSM in dealing with humanitarian issues has become increasingly significant, and both empirical studies (Dittus, 2016) and this study indicated that the aspect was an important attractor for contributors. The aspect offers contributors opportunities to help others who are disadvantageous and vulnerable affording their altruism motivation.

6. CONCLUSION

Volunteered Geographic Information (VGI), as commented by Goodchild (2008), is one part of the broader transition in the world of geographic information. The production and consumption of geographic information become localized at the hands of citizens rather than centralized at authoritative agencies (Goodchild, 2008). Technology development in the past two decades has introduced the participation of citizens into the arena of creating geographic information, which leads to the rise of VGI. VGI integrates local knowledge and collaborated efforts of citizens. It facilitates the mapping of areas where traditional mapping agencies are not interested, adding attribute information of ground features, and providing rapid notification of changes. However, challenges also emerged: how to engage more contributors and quality assurance, and they should be addressed to take advantage of the benefits brought by VGI.

Gamification, which uses game elements to increase engagement, has been explored in VGI context to address the challenges. However, though the practices and investigations of current gamification instances proliferated, there lacks research investigating the efficacy of these gamification instances. Deterding (2011) argued that simple transfer of game elements in non-gaming systems may not lead to similar motivational affordances, which further indicates the necessity to investigate the efficacy of gamification in VGI context.

This research builds on previous works on motivation to contribute VGI and motivational affordances, and has addressed the four research objectives outlined in Chapter One: (1) Identify main motivations to create geographic information on OSM; (2) Investigate contributors' perceptions of used game elements for gamification on OSM (3) Evaluate the efficacy of current gamification on OSM in relation to contributors' motivations; (4) Provide suggestions for future gamification and engagement in VGI context. The research has identified four major motivations to contribute VGI through factor analysis and learned contributors' perceptions of used game elements for OSM from interviews. The combination of knowledge about motivations and contributors' perceptions has facilitated to understand the efficacy of current gamification on OSM as well as to provide suggestions for future gamification and engagement approaches on OSM and in VGI context.

6.1 Motivations

The understanding of contributors' motivations is essential to the advance of VGI process (Elwood, 2008; Flanagin and Metzger, 2008; Haklay & Weber, 2008), and previous qualitative research has proposed many possible motivations (Coleman et al., 2009; Budhathoki et al., 2010; Coleman et al., 2010). This research applied factor analysis to recognise motivations to contribute VGI from the self-indicated online survey. The study extracted four major motivations: self-need regarding community, data improvement, monetary award, and altruism. Both monetary award and altruism were also identified in previous works (Budhathonki & Haythornthwaite, 2013; Coleman et al., 2009; Coleman et al., 2010), and their re-emergence in this study further asserted their roles in motivating contribution. The identification of self-need regarding community echoes previous findings on motivations related to community and suggests that community is an important attractor. Data improvement reflects that contributors volunteer geographic information to achieve the goal of OSM for providing a free world map. The knowledge of motivations to contribute VGI facilitates to classify contributors in accordance with their motivations, and thus approaches that address different motivations can be designed. The findings of motivations to contribute geographic information provide reference knowledge for investigating used game elements in the gamification instances from the perspective of motivational affordance.

6.2 Gamification in VGI context

The use of gamification to motivate contribution has proliferated in VGI context especially on OSM (Celino et al., 2012; Martela et al., 2015), but there is a lack of research exploring the efficacy of the instances. The thematic analysis of the interviews held with contributors on OSM has suggested that contributors perceive currently used game elements not helpful in motivating their contribution to OSM implying negative attitudes toward current gamification on OSM. Statistics and leaderboard, though two commonly used game elements in various context for gamification, are not able to engage OSM contributors as the use of them is not able to afford contributors' motivations. Furthermore, the adverse consequence of competition – cheating and useless contribution – even worsens contributors' perceptions, and demotivate contributors from the use of them. The findings echoed previous works on motivational affordances (Deterding, 2011; Weiser et al., 2015) further suggesting that simple transfer of game elements in a non-gaming context may not lead to similar motivational affordances.

As suggested by Dixon (2011), though some aspects of one domain can be extrapolated to another, game elements, which are originally designed for video games, may not be applied directly for gamification in a non-gaming context. Therefore, it is necessary to develop frameworks that fit gamification into the VGI context. Though the framework proposed by Martella et al (2015) did provide insights into the design of effective gamification in the VGI context, but it only borrows knowledge from video games like Bartle' taxonomy of players without modifying it to fit the VGI context. This study provides extra knowledge on contributors' motivations that can be integrated into the framework, and should facilitate the use of it to develop more effective gamification instances.

6.3 Directions for Future Research

Due to the limited scope of this study, many avenues for future research remain open. The characteristic information has implied that more diverse participants should be recruited. Reproducing this study on a wider scale, through recruiting participants from email lists designated for other countries would yield a more complete view of motivations to contribute VGI as well as the perception of current gamifications on OSM. This type of study may also facilitate to indicate potential differences among contributors with different backgrounds by comparing results from contributors recruited through different email lists. Furthermore, the same survey can be distributed in events in which a lot of new contributors participate, such as Mapathon, to learn motivations of new contributors. The findings of newcomers' motivations will be useful for developing strategies to retain them to consistently contribute VGI.

The suggestions toward engagement provided by interviewees also pointed out directions for future research and practices. The case of Pokemon Go players has demonstrated the potential of advanced game elements and augmented reality games for motivating contribution, thus gamification instances that integrate more advanced game elements should be developed and investigated in the future to examine whether they would yield better motivating impacts. Furthermore, contributors perceive positive feedback more motivating than game elements, thus features that allow contributors to easily provide positive feedbacks on others' works should be added. Previous research (Dittus, 2016) and interviewees in this study have indicated the role of the humanitarian aspect of OSM in attracting and engaging contributors. As suggested by Dittus

(2016), approaches that take advantage of humanitarian aspect to retain contributors and engage them in long-term consistent contribution should be explored and investigated in the future.

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APPENDIX A

Online Survey Questionnaire

You are invited to participate in a research study conducted by Chen Chen, under the supervision of Dr. Peter Johnson, Department of Geography and Environmental Management of the University of Waterloo, Canada. The study is conducted as part of Chen's thesis research project for a Master of Science degree in Geomatics. The objectives of the research study are to understand the motivations to contribute volunteered geographic information (VGI) and to explore the appropriate game elements in VGI context.

If you decide to participate, you will be asked to complete a 20-minute online survey. Survey questions focus on your personal experience with and reason to contribute OpenStreetMap**.** Participation in this study is voluntary. You may decline to answer any questions that you do not wish to answer and you can withdraw your participation at any time by not submitting your responses. There are no known or anticipated risks from participating in this study.

It is important for you to know that any information that you provide will be confidential. All of the data will be summarized and no individual could be identified from these summarized results. Furthermore, the web site is programmed to collect responses alone and will not collect any information that could potentially identify you (such as machine identifiers).

In appreciation of the time you have given to this study, you can enter your email address into a draw for a $50 Amazon Gift Card. Your odds of winning the prize is based on the number of individuals who participate in the study. Information collected to draw for the prize will not be linked to the study data in any way, and this identifying information will be stored separately, then destroyed after the prize has been provided. The amount received is taxable. It is your responsibility to report this amount for income tax purposes.

This is an anonymous survey unless you either enter your email address for the draw or agree to provide your contact information in the question that helps us to contact you for follow-up interview. If you select not to participate in the draw or provide your contact information in the question, the researchers have no way of identifying you or getting in touch with you. When information is transmitted over the internet confidentiality cannot be guaranteed. University of Waterloo practices are to turn off functions that collect machine identifiers such as IP addresses. Survey Monkey™ may collect this information without our knowledge and make this accessible to us. We will not use or save this information without your consent. If you prefer not to submit your responses through this host, please do not sign up for this study. The data, collected from this study will be maintained on a password-protected computer database in a restricted access area of the university. As well, the data will be electronically archived after completion of the study, maintained for 1 year and then erased.

Should you have any questions about the study, please contact either Chen Chen (c226chen@uwaterloo.ca) or Peter Johnson (peter.johnson@uwaterloo.ca). Further, if you would like to receive a copy of the results of this study, please contact either investigator.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. However, the final decision about participation is yours. If you have any comments or concerns resulting from your participation in this study, please feel free to contact

Dr. Maureen Nummelin in the Office of Research Ethics at 1-519-888-4567, Ext. 36005 or maureen.nummelin@uwaterloo.ca.

Thank you for considering participation in this study.

Consent to participate

If you agree to participate in the survey, please proceed to fill in the questionnaire. Otherwise, please close your browser window now.

Section A:

In this section, we will ask about your personal experience with and reason to contribute OSM. Please indicate how much you agree with following statements from 1 to 7.

Strongly Agree: 7, Agree: 6, Somewhat Agree: 5, Neutral: 4, Somewhat Disagree: 3, Disagree: 2, Strongly Disagree: 1

	1	2	3	4	5	6	7
1. I contribute to OSM because I cannot find map data that fits my needs elsewhere. [1]							
2. I contribute to OSM because the map data can be downloaded for free.							
3. I feel happy that others use my contribution to OSM.							
4. My contribution to OSM can help solve many social issues such as natural hazards or emergency responses.							
5. I contribute to OSM because it is an alternative to other map platforms such as Google Map							
6. I contribute to OSM because I saw many errors on it. [1]							
7. I contribute to OSM because I find places I know are missing from the platform. [1]							
8. I contribute to map data in the area I live because I want others to know the area.							
9. I can earn technical skills through contributing to OSM. [2]							
10. Part of my job responsibilities require me to contribute to OSM.							
11. I believe my contribution will help me in my career. [1]							
12. I benefit from contributing to OSM financially.							
13. I feel recognized by contributing to OSM. [1]							

14. OSM community is important for me to contribute to OSM.							
15. I enjoy interacting with other OSM participants. [3]							
16. I contribute to OSM because I enjoy Mapathon.							
17. I enjoy the process of contributing to OSM. [1]							
18. My OSM experiences have added richness to my life.							
19. OSM allows me to express my knowledge and expertise. [3]							
20. I believe in the OSM goal of creating of a free, open map of the world							

** Mapathon (previously Editathon) is a coordinated OSM mapping event or mapping party, in which contributors gather at a certain place to contribute to OSM together*

[1] Budhathoki, N. R. (2010). Participants' Motivations To Contribute Geographic Information in an Online Community, 115. Retrieved from https://www.ideals.illinois.edu/bitstream/handle/2142/16956/1_Budhathoki_Nama.pdf?sequence=2.
[2] Clary, E. G., Snyder, M., Ridge, R. D., Copeland, J., Stukas, a a, Haugen, J., & Miene, P. (1998). Understanding and assessing the motivations of volunteers: a functional approach. Journal of Personality and Social Psychology, 74(6), 1516–1530.
[3] Gould, J., Moore, D., Mcguire, F., & Stebbins, R. (2008). Development of the Serious Leisure Inventory and Measure. Journal of Leisure Research, 40(1), 47–68.

Section B:

In this section, please indicate your attitudes towards the current practices of gamification in OSM and the potential of gamification in VGI context.

** Note: if you have not experienced the practices identified in following questions, we would still like to hear your views on them.*

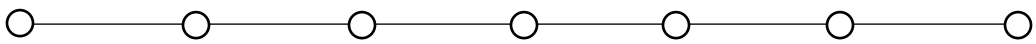
1. Which gamified applications based on OSM have you experienced?

□ BattleGrid □ MapRoulette □ Kort □ Urbanopoly

□ Others (Please indicate) or None _____

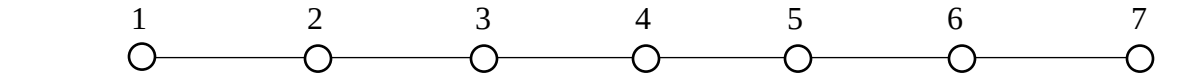
2. Please indicate the overall level of fun you experienced using those gamified applications from 1 to 7, which indicates extremely boring to extremely fun.

1 2 3 4 5 6 7



Extremely Boring Extremely Fun

3. Do you agree that you are more motivated to contribute to OSM through such applications? Please rate from 1 to 7, which indicates Strongly Disagree to Strongly Agree.



4. If you have experienced such applications, what attracts you most?

□ Receiving quests for tasks

□ Rewards for completing tasks

□ Being able to compete with other users

□ Others please indicate what attracts you most _____

5. Please rate how motivated you are by the following game elements in continuously playing a game from 1 to 7, which indicate from extremely demotivated to extremely motivated.

Game Element	1	2	3	4	5	6	7
Achievements							
Avatars							
Badges							
Leaderboards							
Levels							
Points							
Quests							
Teams							
Narrative story							

6. Please indicate any other game element which you have experienced and also rate it from 1 to 7 as question 5.

_____

_____

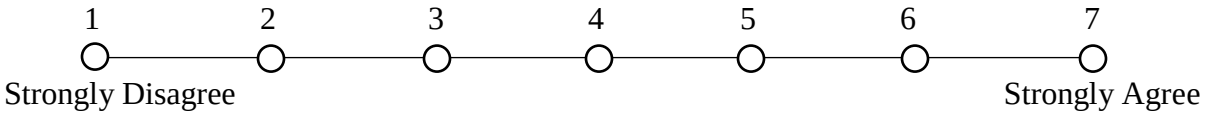
_____

7. Do you have experience with Mapathon*? If you do not have experience with Mapathon, please skip question 7 to 9.

** Mapathon (previously Editathon) is a coordinated OSM mapping event or map party, in which contributors gather at a certain place to contribute to OSM together*

□ Yes □ No

8. Do you agree that you are more motivated to contribute to OSM during a Mapathon? Please rate from 1 to 7, which indicates Strongly Disagree to Strongly Agree.



9. Which part of Mapathon do you find most attractive and why?

_____
_____
_____

10. Have you experienced augmented reality (AR) and location based games (e.g. Ingress)?

** If you have not experienced such games, please skip question 10 & 11*

□ Yes □ No

11. If you have experienced AR and location based games, what attracts you most in the games?

_____
_____
_____

Section C:

In order to help us to better understand your responses, we would like to ask you a few questions about your background and experience with OSM.

1. Gender:

□ Female □ Male □ Other

2. Age Category:

□ Under 18 yrs □ 18 – 30 yrs □ 31 – 45 yrs □ 46 – 60 yrs □ Over 60 yrs

3. Which country are you from: _____

4. How long have you been contributing to OSM:

□ Under a half year □ A half year to 1 year □ 1 to 3 years □ Over 3 years

5. How often do you contribute to OSM:

□ Several times a day □ Several times a week □ Several times a month

□ Several times a year □ Not at all

6. In appreciation of the time you have given to this study, you can enter your email address into a draw for a $50 Amazon Gift card.

Email Address: _____

7. Please indicate your OSM ID, and e-mail address, if you like us to contact your about a follow-up online focus group. You will receive $10 in appreciation of your time in participating the online focus group.

OSM ID: ________________________ E-mail address: ________________________

APPENDIX B

Interview Guide

1. What are your experience with OpenStreetMap

(*Experienced or active contributors are expected to encounter web applications such as BattleGrid and MapRoulette as they direct contributors to area where data manipulation is needed)*

    a. Do you use any applications to guide you to find where to make contribution? (expected answers: BattleGrid MapRoulette)

        i. What are your experience with these applications (BattleGrid and MapRoulette)?

        ii. In addition to BattleGrid and MapRoulette (which are really common), have you experienced with applications which embed richer game elements? (expected applications such Urbanopoly)

        iii. Do you feel motivated to contribute to OSM through these applications?

            1. Do you think the gamification mechanics applied in those applications afford your motivations to contribute geographic information?

            2. What are your views on the current practices of gamification in VGI context?

2. Have you participated in Mapathon before?

(*Mapathon is a coordinated mapping event, in which OSM contributors gather at a certain place to contribute to OSM together)*

    a. What are your experience with Mapathon?

        i. Which previous Mapathon did you participate?

        ii. How long was the event?

        iii. What did you map during the event?

        iv. What do you like most and least about Mapathon?

            1. Competition element

            2. Cooperation element

            3. Social element

            4. Etc.

3. Virtual Reality (VR) and Augmented Reality (AR) are hot topics nowadays, what are your views on the use of such technology in collecting geographic information.

    a. Visualization of geographic information – quick feedback of contribution

b. In support to implement games that collect geographic information