



# **Proceedings of the 16th European Conference on Research Methodology for Business and Management Studies**

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basis), find it develop their independent and critical thinking capabilities (e.g. there was no existing standard to be right or wrong, they are free to build the theory as they like) and the opportunity to be creative (e.g., creating category labels, naming a theory, presenting their work). Although making every effort to simulate the “grounded up” process, it has to be noted that an ideal grounded up process doesn’t exist in reality. Both the prior general knowledge and knowledge on specific topics that may related to GTM act as an existing foundation. Another limitation rest in the limited time in class therefore the data set generated and the sources to collect data is greatly restricted. As a result, the theoretical sampling can not be fully simulated. The last one is the very tentative evaluation on the teaching. Although this tentative evaluation shows that the learning outcome is satisfactory from the students’ perspective, we need more robust evidence to confirm this.

## **5. Conclusion**

The analysis of the case firstly confirms that it is possible to increase the engagement of students via flipped classroom approaches. By turning the students into active researchers, the learning process shows characteristics of transforming from top-down predesigned teaching to grounded-up proactive learning. General teaching activities are seen as top-down arrangement, highlighting the roles of tutors. The case presented in this paper is unique as the GTM itself represent an ongoing effort in achieving highly codified knowledge via grounded up analysis. This conflict is reflected by the various challenges identified in the case, for example, to fully simulate the “grounded-up” process and to minimize the influences from prior knowledge on the topic. In the case the tutors attempted to address the epistemology and ontology issues by asking a number of questions. It is not a fully positive outcome that these questions efficiently and effectively guide the students reflect on the fundamental epistemology and ontology issues in research. However, it explored and provided an innovative way of addressing philosophical problem by questions that are set into everyday context. The case in general is a successful attempt to transform the learning process into a piece of research. The case study is only exploratory and not aiming to generalize every aspect of its conclusions into other context (teaching other research method), but it raises the question that whether we can implement similar designs into the teaching of other research method too, for example, using the teaching of case study method as a case to achieve the most proactive learning. Given the nature of research in business and management studies, it may be easier than the pure science and engineering field to adopt this flipped design. Future studies should be conducted to explore the feasibility of transforming the teaching and learning into more various forms of research projects.

## **Acknowledgements**

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# Applying Qual-Quan Mixed Methods Design in Smart City Research

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**Abstract:** The concept of the ‘smart city’ is becoming increasingly important worldwide. However, a lot of current studies of smart cities focus merely on technical and engineering aspects, and neglect the fact that there is a wide range of social, political, cultural, organizational, economic and human challenges and problems associated with the design, development and deployment of smart city solutions. In other words, more research will need to be done on the socio-technical aspects of smart cities in order for the smart vision to become reality. In light of this discussion, this paper proposes and argues that mixed methods research design could be very suitable and useful for researchers to carry out socio-technical studies of smart cities. This paper particularly focuses on QUAL-QUAN sequential mixed-methods design, which contains a qualitative component followed by a quantitative component with the aim to complement and further validate the qualitative findings. The authors also used a recent research project as an example to illustrate how this research design can be applied in smart city studies. This project aims to investigate potential change management interventions that can be used to support the implementation, deployment and usage of smart transportation solutions in one of the most advanced smart cities in China, namely Shenzhen. The study firstly adopted a case study approach (with semi-structured interviews as the data collection method) to explore the phenomenon under investigation within key local government departments; a cross-sectional questionnaire survey was then carried out on the general public to verify and valid the interview results. It is concluded in this paper that the features and strengths of mixed-methods design are highly useful and valuable for smart city research, which often covers very sophisticated socio-technical issues and involves multiple parties of stakeholders (e.g. government, industry and the general public).

**Keywords:** mixed methods design, smart city, QUAL-QUAN, case study, survey

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## 1. Introduction

With the increasing concern from governments and businesses, the common purpose within the ‘smart city’ concept is to improve the efficiency of the city infrastructure and provide more services to enhance the sustainability of the urban residential environment, to improve the quality of citizens’ daily lives and boost the development of the economy (Neirotti et al., 2014; Nam and Pardo, 2011). A smart city can be established through comprehensive support for, and widespread usage of, advanced Information and Communication Technologies (ICT) such as smart mobile apps, smart hardware devices, smart software applications, and smart data store technologies (Peng, Nunes and Zheng, 2016), which can enhance the city’s usability of resources in a variety of urban environments. Therefore, ICT is treated as the fundamental technologies to create ‘smart’ services involving several domains of a city (education, healthcare, transportation, building management, resource and energy management, and so on) (Chourabi et al, 2012; Giffinger, Haindlmaier and Kramar, 2010). However, as the importance of smart technologies to the smart city project was recognised, current researchers paid more attention to the technical and engineering factors in recent smart city research than on the socio-technical aspects. Moreover, to the best of the knowledge, no study of information systems yet exists that applies a mixed methods approach to smart city research. To some extent, it is an innovation in smart city research that the current researchers are interested in. Furthermore, as the use of the mixed methods approach is increasing in a variety of research settings, it is argued that researchers benefit from adopting a mixed methods design; for example, by better understanding the research questions and problems; reducing the limitations of using single research methods; and combining the advantages of qualitative and quantitative methods (Tashakkori and Teddlie, 2003). However, as applying a mixed methods approach is more difficult than applying a single approach, researchers need to consider carefully the particular research questions and context being examined.

This paper provides an in-depth discussion of applying mixed methods design to smart city research. It aims to offer smart city researchers a wider choice of research methods when they design a smart city study, and to make better decisions by applying a mixed methods approach. This paper also uses a single research case as an example to illustrate the implementation of mixed methods design. The structure of this paper is organised as follows. The first section discusses and clarifies the concept and background of smart city research, followed by



introducing the mixed methods approach and the strengths of applying a mixed methods design compared to using single qualitative or quantitative methods. Subsequently, the following sections provide a recent research project as an example (applying Qual + Quan approaches) to illustrate how mixed methods design can be implemented in practice in smart city research. Finally, conclusions are drawn with suggestions for smart city researchers when they adopt mixed methods design.

## **2. Smart city**

### **2.1 Overview of literature on smart city**

Based on an extensive review of the current literature, it was found that the concept of the smart city is updating and changing constantly, and is defined and used all over the world in different contexts and with different meanings; this is due to different aspects of the smart city being stressed. Although there is no consensus on the definition of a smart city (Alawadhi et al, 2012), it is commonly agreed that ICT is one of the key elements necessary to build a smart city in order to provide timely and efficient information and convenient services to local citizens and enable them to have a smarter living environment (Peng, Nunes and Zheng, 2016).

The initiative of the smart city can be divided into several domains. There are various methods used to understand the smart city that are mainly linked to two aspects: one aspect is that cities can be self-motivated to accomplish the purpose of optimization; another aspect is the application domains that are crucial for a more intelligent use of urban resources (Washburn et al, 2009). A series of current related literature indicates that the domains of a smart city are of two main types based on their tangible and intangible assets: the tangible assets are hard domains including energy, natural resources, waste management, public lighting, water management, transportation, buildings, healthcare and public security; while the soft domains consist of education, the economy, social welfare, government and public administration (Neirotti et al, 2014). Based on their analysis, the domains identified can be summarized as six main application domains for a smart city, which can help to solve relevant problems including natural resources and energy, the environment, transportation, buildings, government, mobility and human domains (Yigitcanlar and Lee, 2014). However, referring to the current situation of smart cities, the popular areas of a smart city are transportation, energy, healthcare, education, public safety, building management, and waste management, which are described in the following (Chourabi et al, 2012; Giffinger, Haindlmaier and Kramar, 2010; Belissent, 2010; Neirotti et al, 2014).

- Smart transportation services. They can optimise transportation in urban areas by considering the traffic conditions, traffic problems and energy consumption. They provide public transportation users with real-time and multi-modal information to create an efficient traffic management and transportation system; they also assure sustainable public transportation by using environmentally-friendly fuel and innovative transportation systems (Nam and Pardo, 2011).
- Smart energy services. They can inform users about energy consumption, calculate the amount of energy that the users require, and only deliver the calculated amount of energy which can reduce the unnecessary energy waste problem and make users aware of their actual demand for energy (Belissent, 2010).
- Smart education services. These can enable teachers and students to use ICT tools to increase the number accessing educational content, and help schools to achieve higher performance and effectiveness levels through capitalizing on educational systems programmes (Zhang, 2010).
- Smart healthcare services. These services offer the benefits of diagnosing and preventing disease, and enabling citizens to access an effective healthcare system with appropriate facilitates and services through use of ICT solutions and remote assistance (National Research Council, 2000).
- Smart public safety services. The purpose of smart public safety services is to make full use of the ability and reaction times of the safety services to deal with issues as they emerge, control a large number of events, improve the public governance transactions and workflows to a higher safety level, and provide surveillance for safety purposes in public areas (Belissent, 2010).
- Smart building management services. These services are used to build resource-saving environments for the areas where people live and work, and to make full use of natural resources through adopting sustainable building technologies.
- Smart waste management services. The purpose of these is to effectively manage daily waste through applying innovations such as smart dustbins in households, public area and business buildings (Peng, Nunes and Zheng, 2016).

## 2.2 The current situation of smart city research

Referring to the previous literature, it is a significant fact that the smart city is not only related to technologies, although advanced ICT is the key element in smart city definition (Nam and Pardo, 2011). To be more specific, some researchers mentioned that apart from technologies, there are other key factors that can determine and influence a successful smart city service, which are the institutional factor and the user factor (Nam and Pardo, 2011; Chourabi et al, 2012). During designing and implementing a smart city service, it is necessary to consider relevant government departments; for example, a smart transportation project could be launched and conducted by local government transportation departments. However, the organisational problems arising from the related government departments considered could become potential reasons for smart project failure, such as poor management, staff resistance or holding different opinions about the purpose of the project (Peng, Nunes and Zheng, 2016). Another significant element influencing the success of smart city projects is user factors, such as the awareness of new smart city services, the acceptance and usage of them, user participation, and the capacity of using new technology in smart city services.

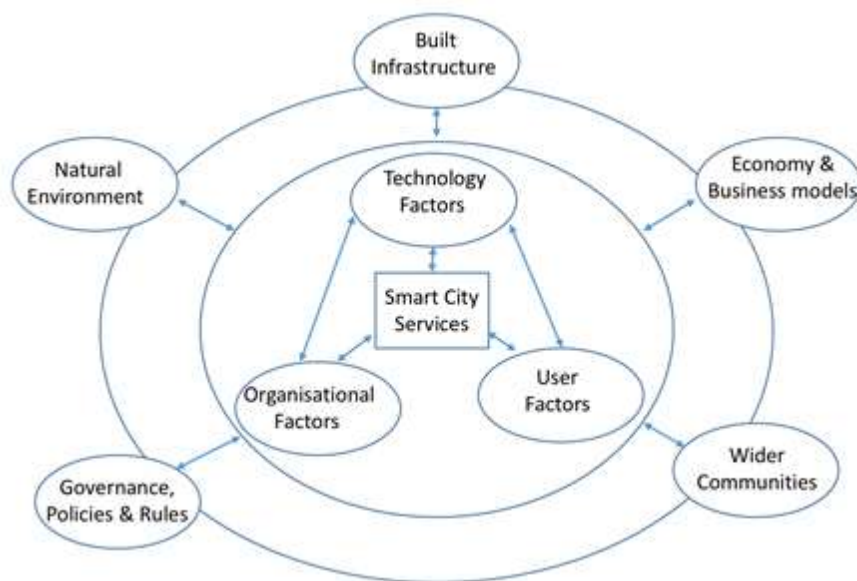


Figure 1: Smart city services framework (Peng, Nunes and Zheng, 2016)

In practice, based on the extensive literature review, most of the current smart city research focuses just on the technical and engineering aspects of the smart city, such as the land use-transportation engineering model, the smart city as a testbed, and whether technology could be used for housing data (Yamagata and Seiya, 2013; Sanchez et al, 2014; Yamamoto, Matsumoto and Nakamura, 2012). That means the current literature neglected a set of crucial non-technical elements such as social, political, cultural, organizational, economic and human challenges, which are related with and affect the design, development and implementation of a smart city, as shown in Figure 1. Thus, this shows that Information Systems (IS) researchers are lagging behind the actual smart city development situation. In addition, from the practical viewpoint, service providers or government managers in a smart city project have placed more emphasis on the technical and engineering elements when they are in the early stages of designing smart city solutions. Whereas, in the development of smart city technologies, the socio-technical elements increasingly begin to play a key role in facilitating the development of a smart city. Therefore, for IS researchers, further studies will be needed that focus on socio-technical aspects of smart cities in order to facilitate the success of the smart vision. Thus, the mixed methods design approach could be very suitable and useful for IS researchers to carry out socio-technical types of studies in the smart city research area. Moreover, in this paper, we are not aware of any studies or information systems papers applying a mixed methods design in smart city research when this paper was written.

## 3. Mixed methods research

### 3.1 Definition of mixed methods research

Mixed methods research refers to a single study that includes both qualitative and quantitative data collection, combines two types of data, and uses a unique design with philosophical assumptions and a theoretical

framework (Creswell, 2014). The combined approaches can enable researchers to better understand the research questions and problems than from only using either approach on its own. The concept of mixed methods research is well defined as a study where researchers collect and analyse both qualitative and quantitative data, integrate the findings from the two methods, and draw conclusions in one single inquiry (Tashakkori and Creswell, 2007). Moreover, according to Fidel (2008) and Peng and Annansingh (2012), it is stressed that the word ‘mixing’ is the main focus of mixed methods research, and needs to be considered in the different processes of the research. The first is the design stage; the characteristics of each selected method should be included in the research design. The second is during data collection. One research method needs to provide perceptions on improving the data collection processes of the other research method in the same study. The third is during the data analysis stage. The results from the collected data from all research approaches should be integrated and supported interactively.

### 3.2 Types of mixed methods design

Referring to the definition of a mixed methods approach, the design can be flexible without any restriction (Peng and Annansingh, 2012). According to Tashakkori and Teddlie (2003), based on reviewing the extensive literature, they mentioned that there were more than forty mixed methods designs applying at least two qualitative and quantitative research methods in sequence or concurrently in the area of social science research. However, Creswell (2003) pointed out six types of mixed methods design which are popularly applied by researchers, as shown in Table 1. In fact, as there are various types of established design, there is no best design way for mixed method research. In practical terms, researchers need to choose the design approach based on the specific research questions and the objectives in the particular context under study.

**Table 1:** Six types of mixed-methods design (Creswell, 2003)

Mixed-methods design	Characteristics
<b>Sequential design</b>	
<b>Sequential explanatory design</b>	This design contains two phases and is characterized by the collection and analysis of quantitative data followed by the collection and analysis of qualitative data. The priority is given to the quantitative part. The purpose of this design is to use qualitative results to further explore and explain the findings of a primary quantitative study.
<b>Sequential exploratory design</b>	This design has an initial phase of qualitative data collection and analysis. This qualitative component is then followed by a phase of quantitative data collection and analysis with the aim of increasing generalizability of the findings. The priority is given to the qualitative aspect.
<b>Sequential transformative design</b>	This design contains two distinct data collection phases. However, either method may be used first when collecting data, and the priority can be given to either the quantitative or the qualitative phase.
<b>Concurrent designs</b>	
<b>Concurrent triangulation design</b>	In this design, both quantitative and qualitative methods are used simultaneously in one phase, with the aim to confirm and cross-validate findings. Both components are equally important.
<b>Concurrent nested design</b>	This design contains one data collection phase, during which both quantitative and qualitative data are collected simultaneously. However, one method (either quantitative or qualitative) must take the predominant position.
<b>Concurrent transformative design</b>	This design combines the features of both concurrent triangulation and concurrent nested designs. Specifically, it may involve a triangulation of quantitative and qualitative components that are equally important. It is also embedded with a supplement method to further explore the issue.

### 3.3 Strengths of mixed methods design

It is stressed by researchers that both qualitative and quantitative approaches have advantages and limitations; thus, applying mixed methods in the research can effectively draw on the strength of both the qualitative and quantitative approaches, and so overcome the limitation of only using one research approach (Creswell, 2003; Tashakkori and Teddlie, 2003; Peng and Annansingh, 2012). Specifically, compared to only using a single approach, the mixed methods approach can answer an extensive and more sophisticated range of questions. It enables researchers to provide stronger evidence to produce a more comprehensive conclusion through generating convergent and corroborative findings, and to achieving more generalizable results (Johnson and Christensen, 2008). That means it enables researchers to become more confident in their results compared to using single research methods on their own. Another significant strength of the mixed methods approach is that it can neutralize the potential biases that may come from use of a single research method (Creswell, 2003).



In summary, the mixed methods approach not only can gather the strengths from each single method approach, but also enable researchers to investigate more complex issues in an extensive range (Fidel, 2008). Therefore, the mixed methods approach is deemed to be appropriate to adopt in examining smart city issues, which may for example contain various elements, such as organizational, socio-political and cultural elements.

#### **4. Mixed methods design in smart city research**

Even though applying a mixed methods approach has a range of benefits for research; however, it is not easy to create an appropriate design and to implement it in practice in a particular smart city context. It is commonly agreed that the mixed methods approach enables researchers to have more flexibility to design the study, and to consider research questions and problems comprehensively (Peng and Annansingh, 2012). Specifically, the application of a mixed methods approach requires researchers to consider how to combine qualitative and quantitative approaches including whether the order is sequential or concurrent; the priority given to each method during the design stage also needs to be considered and whether both are equally important or one approach is more important than the other (Fidel, 2008; Creswell, 2014; Peng and Annansingh, 2012). In addition, researchers must think carefully about how each part of the methods can be used, and which parts are needed to achieve which objectives. It is necessary to mention that all the above questions need to be answered based on the initial research questions and research context.

In the light of this discussion, in smart city research researchers need to consider issues such as: whether or not the research needs diverse views based on the research questions; whether or not single research methods are insufficient in generating reliable results; and whether or not it is feasible to collect both qualitative and quantitative data under the specific settings and context of a study. In fact, if researchers choose unsuitable methods at the design stage, it will not only influence the reliability of the research design, but also affect the richness of data and validity of the research results (Fidel, 2008; Peng and Annansingh, 2012). It is obvious that the qualitative and quantitative approaches are very different in terms of rationale, tools of data collection, and ways of data analysis. It thus needs researchers to have the right and positive attitudes and sufficient ability to design the research approach and overcome further issues that happen in applying mixed methods design (Creswell, 2014). As the purpose of the smart city is to improve the quality of citizens' lives, it may involve collecting data from citizens or service providers, such as sensitive governments, private businesses, and smart city advocates, which is necessary to consider initially how to access them to collect data, and how to get sufficient data. In summary, the issues mentioned above can become obstacles to integrating both qualitative and quantitative findings at the last stage (Bryman, 2007).

#### **5. The research case: Change management interventions supporting the implementation of smart transportation in China**

In order to turn the above theoretical discussion into actual practice and provide further guidance, this section presents a recent study as an example to better explain how a mixed methods approach can be designed and applied in smart city research. This study applied a sequential exploratory (QUAL+QUAN) design as proposed by Creswell (2003) as mentioned in a previous section.

##### **5.1 Research background, aims and objectives**

City governors all over the world have invested heavily in smart city technologies and solutions. The purpose of smart cities is to provide more efficient ICT-enabled services in different city areas and provide real-time information to enable local citizens to have a smarter living environment. However, the mere provision of new technologies and services can neither ensure enhancing citizens' awareness and usage of smart city services, nor be enough to motivate citizens to change their existing behaviours and established ways of doing things that can often be harmful to the environment and/or lead to energy waste (Peng, Nunes and Zheng, 2016). Moreover, a lot of evidence has shown that the failure of implementation of smart city services is very often due to the lack of change in citizens' perceptions, habits and modus-operandi. It is significant to consider how to make the citizens themselves consider participating in the change and be willing to work corporately for the same purpose, understanding the benefits and delivering the expected outcomes in the same city services (Bröchner and Badenfelt, 2011). However, there seems to be a lack of research in relating change management to the smart city and there is no known literature that focuses on the change interventions for citizens.

There are various smart areas included in smart city research. This study, however, chose one of the hottest topic areas in smart city development which is smart transportation services. The research project thus is aimed



at investigating change management interventions that the service provider applied to facilitate acceptance and usage of new smart technologies from citizens in smart transportation services in the Chinese context. Based on the investigated interventions, the preparation processes in order to ensure the implementation of interventions, and the challenges that can affect the implementation will be identified as well. It also attempted to make recommendations to city councils in the first tier of cities who will be aiming to implement smart transportation technologies in Asia. In order to achieve these aims, change management is included as one of the project management practices in order to address problems when a change happens or to reduce changes which may happen and will destroy the project stage (Zhao et al, 2009). These change interventions are applied as a set of structured activities for making people change accomplish an expected result. Accordingly, the subject of this research can be better studied by investigating and exploring individual perceptions and experiences from service providers. This means we need to explore and understand the activities and interventions applied by service providers when implementing a new smart transportation service, as well as to capture their experience and interpretations of how to ensure the implementation of such interventions on citizens.

## 5.2 Research methodology and design

This research adopted a sequential exploratory mixed methods design (Creswell, 2003), which includes two-phases: the first is qualitative data collection and analysis in order to develop a set of exploratory findings; the second is quantitative data collection and analysis which is used to test and verify the initial qualitative findings. This research has selected case study as the predominant methodology; survey was adopted as the approach to support the results from the case study. The research aims at investigating change interventions implemented by service providers for smart transportation in the Chinese context and intends to answer a set of ‘what’ and ‘how’ questions in order to generate valid theories. Based on this, this study adopts a single case study approach for the first stage of this mixed methods research. The case study selected is one of the most developed cities in China (namely Shenzhen) and is used to explore qualitatively particular change interventions that city service providers may apply in smart transportation projects. Subsequently, considering that change interventions in smart cities will be designed and applied to public citizens, it is necessary to investigate public users’ perception of the change interventions generated from service providers in order to ensure the validity and effect of interventions, which will apply survey to achieve the test.

## 5.3 Stage 1: Qualitative research design

Case study is selected when researchers aim to investigate a real-life phenomenon within a significant contextual situation in depth (Robson, 2002). As this research is located in a typical Chinese smart transportation context, and based on the aims of this research, case study is considered a suitable strategy for this study. The city selected in the case study is a developed city in China with rich experience in smart city projects, called Shenzhen. This city has various smart transportation projects implemented during these years that developed dramatically, which can be considered as a typical example in China.

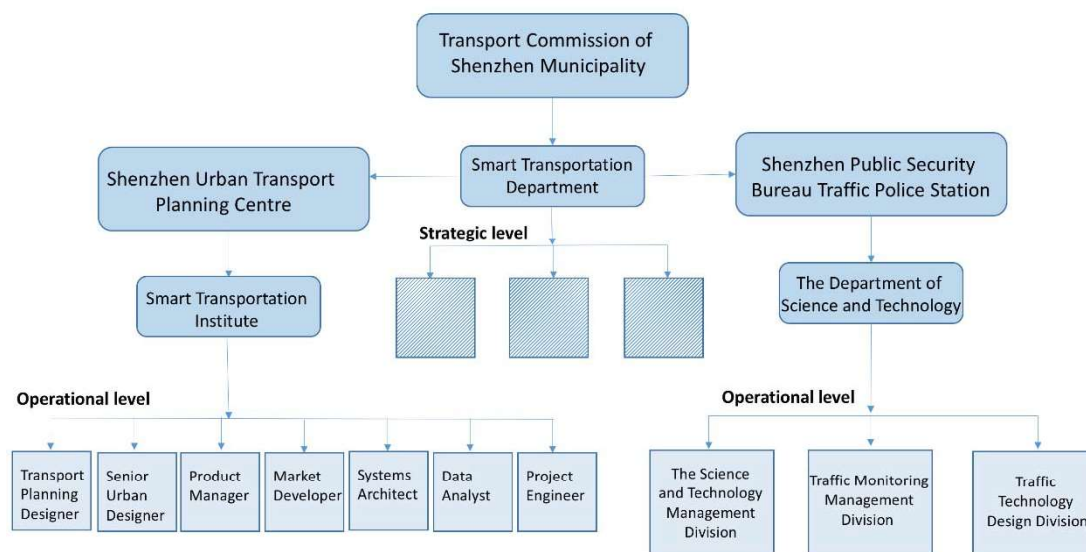


Figure 2: Government departments involved in the research project

Semi-structured interview was selected as the qualitative data collection tool which requires the researchers to prepare a list of questions that need to be considered while deleting or changing some questions in particular interviews based on the researchers' judgement (Mark, Philip and Adrian, 2009). As the purposes of qualitative research are to investigate change interventions and a set of preparation and challenges associated with the implementation of interventions from service providers in Shenzhen city, a deeper interaction with interviewees is necessary to explore information and knowledge from the interviewee's perception and experience. As the term 'service providers' in China mainly refers to the services provided by government departments, there are three main government departments driving the smart transportation project in Shenzhen, including the Smart Transportation Department in the Transport Commission of Shenzhen Municipality, the Smart Transportation Institute in the Shenzhen Urban Transport Planning Centre, and the Department of Science and Technology in the Shenzhen Public Security Bureau Traffic Police Station, as shown in Figure 2. A typical project team consists of the structural level and the operational level. The Transport Commission of Shenzhen Municipality is in charge of getting permission for a new smart transportation project from city council, and then passes the project on to the Shenzhen Urban Transport Planning Centre, and the Shenzhen Public Security Bureau Traffic Police Station to plan, design and implement it, as also shown in Figure 2. A total of 25 interviews will be conducted with participants from these three government departments. Considering that the objective is based on participant's individual perceptions and experience, it is necessary to interview different officers in different positions at different levels in order to explore their interpretations of change interventions that they have applied or should apply to facilitate the acceptance and usage by public users, which can enable researchers to get comprehensive answers in answering the research questions.

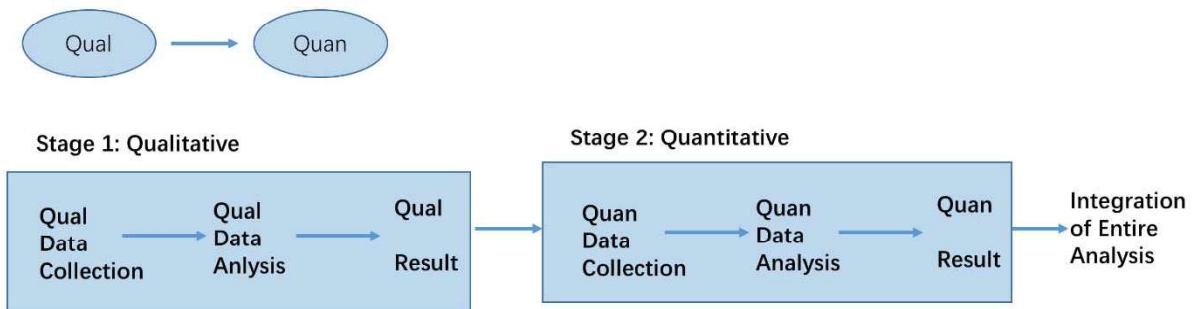
#### **5.4 Stage 2: Quantitative research design**

Further to the qualitative case study, a quantitative survey component will be conducted in the second stage of this mixed-methods design. Based on the findings and hypotheses derived from the case study, the quantitative design is used to test the theory and hypotheses through using a survey instrument. This will be piloted and refined to improve its reliability and validity. More specifically, the purpose of the survey in this project is to investigate the perceptions and opinions of public users towards the set of change interventions as proposed and applied by service providers in Shenzhen city.

The target participants are the general citizens who often use vehicles, such as public transport and private vehicles, and pedestrians, in Shenzhen. A questionnaire is selected as the quantitative data collection tool, which needs to involve participants being asked to respond a set of questions in a predetermined order (De Vaus, 2013). The design of questions in the questionnaire refers to the findings of the qualitative research. As the latest figure for the population in Shenzhen is approximately 10 million, the sampling size is set at around 384 through using a sample size calculator. However, the challenge here is the large size of the population to do probability sampling on. In order to solve this problem, the logic to do sampling is that Shenzhen has 8 Districts, 26 Community Offices and 622 communities. The Community Offices control and manage all the communities' information in their areas. A systemic sampling technique will be used to select the sample of communities. The sample size of communities is approximately 238. We are unable to obtain their residential addresses due to privacy issues. Based on the list of selected communities, we will ask for help from the Community Offices to send out the questionnaires to residents in the selected communities on our behalf.

#### **5.5 Validity of the mixed methods research design**

This research applied mixed methods as a methodology combining both qualitative and quantitative research into one single research study. A mixed methods approach is used to gain stronger evidence to generate the conclusions reached through generating convergent and corroborative findings, and to improve the generalizability of the results (Johnson and Christensen, 2008). In order to ensure the validity and effectiveness of investigated change interventions, the mixed methods approach has therefore been chosen as the most suitable methodology. Moreover, the combination of qualitative and quantitative approaches can produce more thorough and comprehensive knowledge to support theory and practice (Creswell, 2003).



**Figure 3:** Sequential exploratory design adapted from Creswell (Creswell, 2011)

This study used the sequential exploratory design with two stages, as shown in Figure 3. The first qualitative stage is used to explore change interventions used in the smart transportation project in-depth and develop a set of hypotheses, which is emphasised in the research design. The second quantitative stage is used to verify the hypotheses generated from the qualitative stage. The sequential exploratory design is applied when the research needs exploration of data; thus it is applied in this study, where the change interventions and related preparation applied on citizens has not been investigated.

## 6. Conclusion

This paper discussed the use of the mixed methods approach in smart city research in-depth, which intends to solve the limitation of only using either a qualitative or quantitative approach and then generates a more comprehensive findings result. From the above discussion, the implementation of mixed methods design may not always be easy, especially for PhD students and less experienced researchers. It requires researchers to have the ability to make combination between qualitative and quantitative approaches in the whole research including from designing and implementing research to integrating and reporting the findings. Nevertheless, once these can be done effectively and successfully, mixed methods approaches can deliver essential benefits that a single quantitative or qualitative method would not be able to offer. This is particular true for smart city research, which often covers very complicated and multifaceted socio-technical phenomena. In addition, the development of smart cities always involves multiple parties, ranging from governors, to service providers, to industrial partners, to the general public. Mixed methods design can offer very flexible and systematic ways to collect and analyse data from these very different stakeholders as well as to explore the complicated phenomena under investigation, and so leading to more comprehensive and meaningful findings.

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