Collaborative Accessibility-based Public Engagement for Bus Rapid Transit in Pretoria, South Africa

By

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Submitted to the Department of Urban Studies and Planning
in partial fulfillment of the requirements for the degree of

Master in City Planning

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

February 2019

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Abstract

Tools that make use of new technologies and new media to facilitate conversations for dispute-resolution have been studied and tested in various formats in recent years. As a field constantly involved with resolving conflicting interests and seeking collaborative problem-solving, urban planning could benefit greatly from the development and deployment of such tools. CoAXs (Collaborative Accessibility-based Stakeholder Engagement) is an interactive planning tool intended to enhance public participation in planning public transport systems. It has been implemented in different contexts in the United States and in Chile. This thesis presents adaptation and deployment of the tool in a context with distinct political, cultural, and economic characteristics – Pretoria, South Africa. With an ambitious plan to expand its Bus Rapid Transit (BRT) network, but facing constrained road space, Pretoria is two years behind its BRT development plan because of unresolved conflicts between private vehicle users and public transport riders. Using an adapted version of CoAXs that allows users to create scenarios by selecting BRT route options, four public engagement workshops were conducted in July 2018 in Pretoria. The workshops were designed to help learn about the suitability of the tool in a new context, as well as its effectiveness in changing participants' perceptions and attitudes, fostering empathy between interest groups, and supporting meaningful conversations among stakeholders. Using a survey of participants and observations during the workshops, this study finds that CoAXs moderately broadened users' scope of expected impacts and prompted different user groups, especially private vehicle users, to empathize with users of other transport modes. CoAXs was effective in facilitating and supporting public engagement conversations, although more understanding and consideration of the specific cultural context will be helpful in the future.

Thesis Supervisor: Associate Professor, P. Christopher Zegras

Thesis Reader: Professor of the Practice, Ceasar McDowell

Acknowledgements

This work was completed through a lot of uncertainties and difficulties. It is a very valuable experience that would not have been possible without contributions, guidance, and support from many people.

I would like to first thank my advisor, Professor Chris Zegras, for his guidance, understanding, and support. Before getting involved in this project, I have been gaining knowledge and deepening my interests in different aspects of the planning field through Chris's lectures. Through my work on CoAXs and this thesis, Chris has constantly been guiding my thinking, giving me inspirations, and supporting me through difficulties. It has been a great pleasure to learn from him through this project, in the classroom, and beyond the academic work.

I would also like to thank my thesis reader, Professor Ceasar McDowell, for his very helpful feedback and support. Many thanks to the whole MIT CoAXs team: Jonathan Leape, Ricardo Sanchez, Anson Stewart, Xin Zheng, Thiago Sobral, Kelly Blynn, Peter Damrosch, and Cristian Navas. Thanks a lot to Jonathan for helping with the workshops in Pretoria and giving me very helpful suggestions through the project. And special thanks to Anson and Xin, for being so patient with my questions and requests, and helping me learn a lot through the development.

Many thanks are owed to our partners at University of Pretoria: Professor Christo Venter, Nahungu Lionjanga, and all staff at the workshops. It would not have been possible for me to complete this work without the knowledge and guidance from Prof. Venter and Nahungu. Thanks a lot to Nahungu for her commitment to the project, her Sunday night Skype calls, and for taking me on the unforgettable Pretoria Metrorail and minibus taxi tour.

Thanks a lot to the participants in the workshops. Their enthusiastic participation and thoughtful comments helped me to develop a deeper understanding of the context, the complexity of the problem, and the experiment itself.

Thanks to the MIT Department of Urban Studies and Planning and BRT+ Center of Excellence for the funding support to my study and this project. And thanks a lot to all the DUSP staff for the help to accommodate my special thesis timeline.

Finally, I would like to give a very special thanks to my parents, for understanding and supporting my adventures, and for their love and encouragement. Last but not least, thanks in heart to all my friends for their enormous emotional support through my time at MIT.

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Chapter 1: Overview

Public transport development often involves multiple stakeholders with conflicting interests, which makes effective public engagement a critical part of the planning processes. Pretoria, South Africa is one city undergoing such a planning process to expand its Bus Rapid Transit (BRT) network. The conflict between commuters' urgent need for affordable and reliable public transport services and private vehicle users' concern about worsening traffic congestion has been unresolved for over two years through the current public participation schemes. This conflict, combined with constrained road spaces, has interrupted the implementation of the city's BRT plan.

CoAXs (Collaborative Accessibility-based Stakeholder Engagement) is an interactive planning tool intended to enhance public participation in planning public transport systems. It features an accessibility-based visualization of project impacts under hypothetical scenarios that are modifiable by its users. CoAXs has been successfully tested in the United States and Chile, showing potential for broadening project understanding and fostering empathy among different stakeholders. This thesis presents an experiment with an adapted version of CoAXs for the Pretoria context, to explore suitability of the tool in a new context, as well as its effectiveness in changing participants' perceptions and attitudes, fostering empathy between interest groups, and supporting meaningful conversations among stakeholders. The Pretoria project was a collaboration with the University of Pretoria, undertaken as part of the BRT+ Centre of Excellence.

1.1 Background

Pretoria is the administrative capital of South Africa (along with Cape Town as the legislative capital and Bloemfontein as the judicial capital). The metropolitan area has a population of 2.9 million and is located approximately 55 kilometers north-northeast of Johannesburg in the northeast of South Africa. Pretoria is the central part of the Tshwane Metropolitan Municipality in Gauteng Province, and Pretoria itself is sometimes referred to as Tshwane as well.

1.1.1 Public Transport in Pretoria

In July 2012, the City of Tshwane started construction of its bus rapid transit (BRT) system, *A Re Yeng*, and the first phase of the system became fully operational in December 2014. *A Re Yeng* is planned with a trunk-feeder structure. Figure 1 illustrates the completed and planned trunk routes for *A Re Yeng* by the Gauteng Department of Roads and Transport. Currently, the Pretoria BRT consists of 2 trunk routes and 7 feeder routes. The completed and operational trunk routes are Line 1A and Line 2A in Figure 1. They have a total length of 16 kilometers and 12 stations, and run through the Pretoria CBD on dedicated lanes, with stations located on the central median of the road. The feeder routes run across the city to bring passengers to the trunk route, mostly in mixed traffic lanes. The complete system is planned with 16 trunk lines with 80 kilometers total length and 62 stations, among which 5 trunk lines (53 kilometers total) are planned to be implemented within five years. The City of Tshwane is responsible for planning, design, and construction of the BRT, with investment from the Development Bank of Southern Africa (DBSA). The BRT system is operated by Tshwane Rapid Transit (TRT) Pty Ltd, which is a corporate entity monitored by the City. The fare structure of *A Re Yeng* is distance-based, with a tap-in – tap-out payment system via pre-loaded cards.

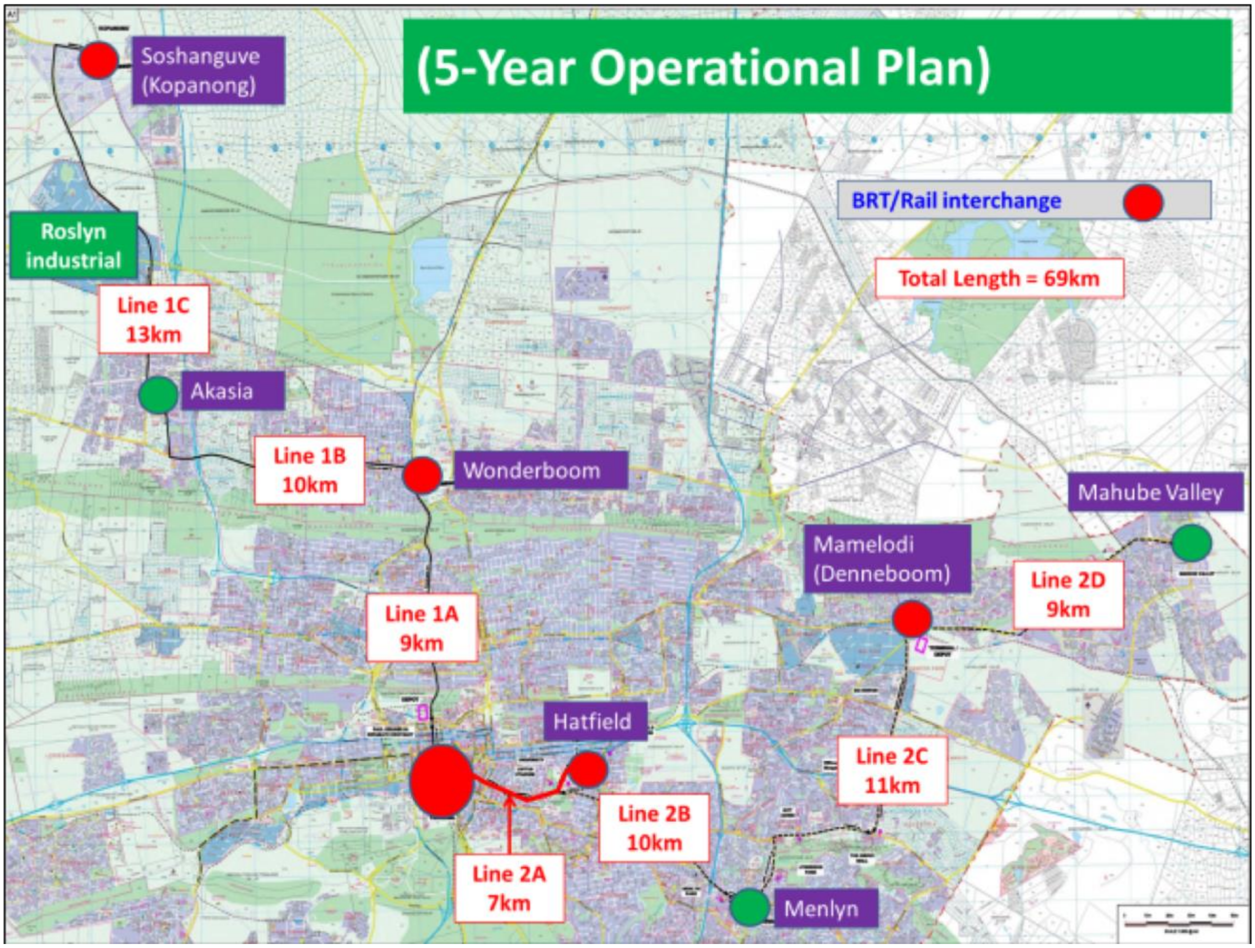

Figure 1: A Re Yeng 5-Year Operational Plan

(Source: Ismail Vadi, 2017)

Currently, Pretoria has five separate formal public transport systems. Aside from the BRT, there are Tshwane Municipal Bus, Metrorail, Gautrain, and Gautrain bus. The Tshwane Municipal Bus is a bus service with fixed routes and timetables. As of July 2017, it requires the same card as *A Re Yeng* as the only payment method, and it has the same distance-based fare structure as *A Re Yeng*. However, there is no fare discount when transferring between Tshwane Municipal Bus and *A Re Yeng*. The Metrorail is a cheap mass transit railway service operating from Pretoria west to Atteridgeville, north to Soshaguve and Ga-Rankuwa, east to Mamelodi, and south to Johannesburg Park Station. It is the most affordable option for workers living in the surrounding townships to commute to the Pretoria CBD on a daily basis. However, because of poor conditions of trains and unreliable schedules, the Metrorail is not considered safe or preferable for commuters who could afford other options.[1] The Gautrain is an 80-kilometer mass rapid transit railway system in the Gauteng province, primarily connecting Johannesburg and Pretoria as an alternative to driving for commuters. It became operational in June 2012, and currently has nine stations, two of which are located in Pretoria. The Gautrain is reliable, fast, safe, but much more expensive, and only connects well developed city centers instead of townships where large numbers of workers live. The Gautrain bus is a feeder bus service that brings people to and from the Gautrain stations. It also operates on pre-defined routes and timetables, and has been used on its own as a commuting option. Except for a fare discount when transferring between the Gautrain and Gautrain bus, there is no fare integration across the five formal public transport systems in Pretoria.

Similar to other South African cities like Johannesburg and Cape Town, there are robust informal minibus taxi services running in Pretoria. The minibus taxis are usually 16-seat vans, operated by one driver only, and known for reckless driving. They run on certain routes but often change routes according to traffic and demand. The fare of minibus taxis is relatively cheap, but more expensive than the Metrorail. Although the safety and reliability of minibus taxis are not desirable, they are more favorable than the Metrorail to passengers, including workers from the surrounding townships if they can afford it ("The minibus taxi industry in South Africa," 2013).

[1] The Metrorail has experienced multiple incidents of fatal accidents, severe delays, and violent protests. The following news articles reported a few of these incidents: "Metrorail trains torched in Pretoria" (2016), "Metrorail trains are running at least an hour late this morning" (2017), and "Metrorail trains suspended between two Pretoria stations after violence" (2018).

1.1.2 Pretoria’s BRT Extension and Contentions

In 2012, the city conducted a feasibility study of the impacts of converting one of the two general traffic lanes to a dedicated bus lane in each direction of Lynnwood Road and Atterbury Road, two of the city’s busiest streets. Based on 2012 traffic data, the study concluded that, aside from the Lynnwood and University Road intersection, the reconfiguration of the two roads would not result in congestion at other spots. The city then released the feasibility study report to support the plan to convert one of the lanes to dedicated bus lane for BRT, leaving only one general traffic lane per direction along the two streets (Moatshe, 2017). However, four independent transport engineers did their own analysis and found that most of the intersections on Lynnwood Road are already experiencing significant congestion in the morning peak period, and they concluded that the results of the feasibility study were implausible (“Tshwane A Re Yeng bus plan ’faulty’,” 2015). The local residents, who experience the congestion, quickly started to oppose the city’s plan (Bothma, 2015).

In April 2015, it was announced that the Line 2B trunk route, which will run between Hatfield and Menlyn (Figure 1), would be completed by June 2017. Four days after the announcement, residents and opposition parties started protesting against the construction of Line 2B, due to the planned reduction in general traffic lanes on Lynnwood Road to one lane per direction. This conflict remained unresolved for over two years, and in January 2018, six months after the date that Line 2B was originally planned to be operational, the city announced its decision to maintain two general traffic lanes per direction on Lynnwood and Atterbury roads, so that the introduction of BRT will not compromise existing road capacity.

With the new decision to maintain existing road capacity, the options for the Line 2B route became:

1) Operate the BRT in mixed traffic, with no major infrastructure construction and the buses being affected by peak-hour congestion with all other vehicles;
2) Construct a new lane in each direction, for exclusive BRT use, taking over spaces currently used as street parking.

Presumably, these two options will have very different impacts on different user groups. Option 1 would minimally impact private vehicle users, but the benefits of BRT for bus riders would be compromised; Option 2 would benefit the BRT users with more travel time savings and reliability by isolating services from congestion, but would reduce parking capacity for private vehicle users. Faced with the possibility of losing parking spaces, in addition to the opposition against BRT accumulated over the past years, the car drivers have maintained resistance to the Line 2B addition even though the previous plan to reduce number of general traffic lanes is no longer under consideration.

1.2 Research Questions

In this context, this thesis attempts to answer three basic questions, using an interactive digital visualization tool, CoAXs (Collaborative Accessibility-based Stakeholder Engagement), deployed in public workshops.

1. Does visualization of accessibility changes influence the public's perception of and attitudes towards the addition of BRT routes?

Here, accessibility is measured by number of job opportunities reachable via public transport in different scenarios. Currently the public's negative perception of BRT results from concerns about it taking limited street space and producing potential densification in their neighborhoods. However, their perceived impacts of the additional BRT routes and attitudes towards them may change from seeing the improved accessibility.

Hypotheses:

1) Workshop participants will generally develop a broader perception and understanding of the impacts of additional BRT routes;

2) Participants' attitudes towards and enthusiasm for additional BRT routes will become more positive;

3) Participants who are private vehicle users are less likely to improve their attitudes towards additional BRT routes than other participants.

2. Could the visualization help develop empathy among transport user groups with conflicting interests, i.e., public transit users and private vehicle drivers?

If the option of constructing an additional lane for BRT is adopted, conflicts in the interests of public transport users and private vehicle users will be more evident, since public transport users will benefit from increased travel speeds for BRT and therefore increased accessibility given time constraints, but private vehicle drivers will lose parking spaces. We expect the two groups will develop more empathy towards each other when visualization of the other group's gains and losses are presented.

Hypothesis: Empathy between the two user groups will improve, people will think more about users of other transport modes.

3. Does the option of interacting with the tool on a laptop in addition to interacting with it on a large touch screen increase or decrease the impacts of the visualization on users?

In previous CoAXs workshops in other contexts, people only used a large touch screen to analyze transport scenarios together with a group of participants. We were curious whether this is the most effective way for people to best understand the scenarios, since some participants have to wait while others are using the touch screen, and some participants may not be comfortable exploring their scenarios of interest in front of a crowd. As such, in the workshops we provided the option of interacting with CoAXs on laptops, so that participants could explore scenarios on their own or in smaller groups if they want to.

Hypothesis: Participants with less public meeting experiences will prefer to use laptops, but the impacts of the visualization will decrease because the users will not see scenarios that are interesting to other participants.

1.3 Thesis Organization

This thesis is organized in the following structure:

Chapter 2 provides the literature review for this thesis, focusing on issues related to public transportation and public participation processes for planning in South Africa.

Chapter 3 summarizes the previous uses of CoAXs, and describes the development and adaptation of the tool specific to the South African context.

Chapter 4 elaborates the experiment design of the CoAXs workshops in Pretoria.

Chapter 5 presents the results of the CoAXs workshops.

Chapter 6 develops conclusions based on the experiment results, and discusses limitations and recommendations for future research.

Chapter 2: Literature Review

2.1 Public Transport in South Africa

The public transport system in Pretoria faces a number of issues, which are not unique among other metropolitan areas in South Africa. This section summarizes the major issues related to the CoAXs experiment in Pretoria, drawing from the literature on public transport in South Africa.

First, the inequitable transport provision and its social consequences on low income populations in the South African context have been studied through the past decades. Most studies focus on low income groups in rural areas in multiple African contexts. For example, some have criticized that road development in rural areas is not a sufficient condition for providing economic opportunities for the poor, given their lack of access to motor vehicles and ability to afford public transport (Bryceson, Bradbury, & Bradbury, 2008). With a more recent shift towards focus on public transport in urban contexts, Venter (2011) used the 2003 National Household Travel Survey (NHTS) data to find that commuters living in displaced urban settlements or in isolated deep rural locations are most burdened by public transport expenditures, because of long commute distances, poor road conditions, and few travel alternatives. Another study focusing specifically on low income groups in Tshwane argues that lack of transport, high travel costs, and resulting limited access to basic activities (e.g. employment, education, health care) have contributed to them being unable to fully participate in the society and becoming socially excluded. The study specifically identified that formal public transport is often not an option for many urban low income residents of the Tshwane region, because the services were not provided at their residential locations or at the time they need to travel (Lucas, 2011).

Second, gender inequality in accessibility has also been an extensively studied issue in the South African, or more broadly, African contexts. In an early study focusing on rural women's transport demand in multiple African countries, Bryceson & Howe (1993) contend that, given the sexual division of labor and women's child-caring responsibilities, women's mobility is often limited to shorter distance range, higher frequency, and slower adoption of improved means of transport. Through a case study of a road development project in Tshitwe, South Africa, Mahapa & Mashiri (2001) argue that, since women had limited access to the means of production but more responsibilities of household sustaining activities, their transport needs are often neglected by policy-makers, which in turn worsens their social exclusion. Focusing on the metropolitan area of Durban, South Africa, a study finds that gender differences in travel behavior are most evident among low-income groups, with the differences also increasing in communities more distant from the city center – women in rural localities have restricted access to car use, long travel distances to work, and higher travel times and costs, while women in the urban core have very similar mobility patterns to men (Venter, Vokolkova, & Michalek, 2007).

Third, although there have been major public transport infrastructure developments in Gauteng Province, their effectiveness in improving accessibility and attractiveness for people to switch from driving have been criticized. For example, based on a trip rate model to predict performance of the BRT system of Johannesburg and Gautrain in scenarios of planned network expansions, one study predicted that, although passenger volume will increase significantly, the modal share of the BRT and the Gautrain in total passenger-kilometers travelled will remain below 4% until 2040 (Bubeck, Tomaschek, & Fahl, 2014). Also looking at the BRT in Johannesburg, using "access envelopes," an accessibility measurement developed specific for the South African context and focused on measuring affordable access to job opportunities, a study predicted that introducing a BRT trunk route would hardly improve the current accessibility provided by the informal minibus-taxi network, and even under the best case scenario with fully integrated feeder routes, affordable job accessibility would only be modestly improved by 6% (Venter, 2016). Another study identified the effects of different factors on customer satisfaction and modal share of the Tshwane Bus Express in Pretoria, finding that reliability, security, and fare are important factors to both users and non-users of the service; users are more sensitive to climate control, payment method, and newspapers provision, while non-users are more sensitive to frequency and information provision (Mokonyama & Venter, 2013).

Fourth, since informal public transport is an important component of public transport in many cities of South Africa, the issue of regulating and formalizing services has also been discussed in multiple literatures. For example, both studies mentioned earlier on the Johannesburg BRT conclude with necessity to integrate the minibus-taxi network. From the perspective of improving service attractiveness, Bubeck et al., (2014) argued that integration with the informal system will help increase modal share of the BRT and the Gautrain, whereas Venter (2016) suggested from the perspective of affordability, fare integration with the minibus taxis is critical to maintaining affordable access for poor passengers, because in a scenario where the taxis are allowed to provide feeder services to the BRT without any fare integration, affordable access to jobs is likely to decrease. Reviewing previously failed state interventions in the minibus-taxi industry in South Africa, Venter (2013) argued that BRT provides opportunities for the minibus-taxi industry to go beyond its current state of stasis, by overcoming the constraints of informality and by opening up new markets. Venter (2013) also identified that success of this formalization process depends on some critical factors: 1) ensuring the financial attractiveness of the BRT participation for taxi operators to capture new scale economies in order to cut down operating costs, 2) expanding taxi operators' markets beyond their traditional enclaves of captive users, and 3) securing an ongoing commitment from former taxi operators, especially those on the margins of the public transport market.

2.2 Public Participation in South Africa

Public participation is a relatively new concept in South African history. Before 1994, African, Colored, and Indian communities were excluded from meaningfully participating in decision making within state and government institutions or structures. Specifically, it was defined illegal for these communities to engage with decision-makers openly and gainfully by statutory mechanisms such as the Group Areas Act and the Population Registration Act under the apartheid government (Mbuyisa, 2013). Efforts to address these injustices and exclusion did not start until the transition to democracy reached the point of the 1994 elections, when the Government of National Unity (GNU) was established. Since 1996, the Constitution guaranteed local government its own sphere of governance, and explicitly defined one of local government's objectives to be "to encourage the involvement of communities and community organizations in matters of local government".[2] This section summarizes the current schemes of public participation at the local level in South Africa from literature, and introduces the key issues related to public participation most discussed by scholars.

Aside from the constitutional assignment of the task of encouraging public participation to the local government, the legal framework of how this task turns into action at the local government level was further formulated by the Municipal Structures Act (1998) and the Municipal Systems

[2] Constitution of the Republic of South Africa, 1996: Section 152(1)(e).

Act (2000). To facilitate the forms of participative democracy outlined in these Acts, the ward committee system was introduced, which has become the main form of public participation in local government. Wards are subdivisions of municipalities geographically defined for electoral purposes. Each municipality[3] is divided into half the number of seats on the municipal council (rounding up if there is an odd number of seats). Each ward elects one ward councilor as the chairperson of the ward committee (Municipal Demarcation Board, 2016). Under this structure, half of the municipality council are elected directly from wards, while the other half of the municipality council are Proportional Representative (PR) councilors, who are elected through their party lists. All councilors are expected to make important decisions by voting in their municipality council on issues such as council resolutions, policy changes, the Integrated Development Plans (IDP) and annual budget.

Ward councilors serve a key role as the interface between the citizens they represent and the municipal officials who design and implement development policies. A ward councilor is responsible for raising concerns to the municipality council on behalf of her ward members, as well as ensuring the municipality implements policies to address the needs of citizens in her ward (Mbuyisa, 2013). The specific responsibilities of ward councilors include:

- giving ward residents progress reports explaining council decisions in committing resources to development projects and programs affecting them,
- assessing intended impact of municipality programs and plans,

[3] There are 284 municipalities in total in South Africa, including 6 metropolitan municipalities, 47 district municipalities, and 231 municipalities, after a rationalization process carried out by the Municipal Demarcation Board from 1999 to 2000.

- assessing whether services are being delivered fairly, effectively and in a sustainable way,
- determining whether capital projects are being rolled out in accordance with IDP,
- keeping in close contact with their constituencies to ensure that the council is informed of all issues on the ground, and
- conveying important information to residents from the council.

Since planning decisions regarding the BRT in Pretoria take place at the local government level (i.e., the City of Tshwane), the ward committee scheme is the main format of public participation specific to the BRT planning (Madumo, 2011). In addition, a public consultation meeting was also required held for each trunk or feeder route proposal by the City ("Stakeholder Engagement," 2015).

Although the ward committee scheme for ensuring public participation around local issues at the municipality level is well defined, scholars have identified a number of issues with this scheme in practice. First, some have argued that marginalized communities are often neglected or unable to participate meaningfully in this scheme. For example, in rural communities, the ward committees were not able to attract diverse, strong and effective participants, which resulted in a failure to achieve equity in representing all social segments and interests (Masango, 2008). As a result, in poorer communities, ward committees often have lower levels of education, which makes it difficult to have meaningful participation with knowledgeable municipal officials within the context of power imbalances (Mbuyisa, 2013). A case study in Johannesburg found that ward meetings in poorer areas are often dominated by questions about unrealized promises, and lists of demands that the municipality is expected to address, instead of raising needs and concerns or reviewing proposed plans (Friedman, Hlela, & Thulare, 2005). Second, the planning process (specifically IDP) has been criticized for remaining highly top-down. For instance, the same Johannesburg case study points out that communities are merely allowed to comment on proposals developed by municipal officials rather than being invited to contribute to proposal content before its drafting (Friedman, Hlela, & Thulare, 2005). Third, logistical constraints also affect the effectiveness of public participation. For example, there is often a lack of technical skills to provide legal interpretation of documents and policy, and a lack of language skills to compile written submissions in ward committees, which result in compromised accuracy in the communication between municipality and ward members (Friedman, Hlela, & Thulare, 2005).

To sum up the literature reviewed in this chapter, inequitable public transport provision in South Africa has imposed financial burdens on, and barriers to economic opportunities for, low-income populations. Recently developed public transport systems have had limited effectiveness in improving accessibility and encouraging people to switch from driving. The planned BRT system in Pretoria could help provide an affordable commute option for marginalized low-income populations, but only with careful planning and design that accommodate the needs of different user groups. However, current public participation processes face barriers to equitable and effective participation and communication across social segments. This context provides an opportunity for testing CoAXs' usefulness in encouraging public engagement across different user groups and bridging the communication gap between the city and the public. The next chapter summarizes the previous uses of CoAXs and describes the development of a new version specific to the Pretoria context.

Chapter 3: Tool Development

3.1 Previous CoAXs Instances

CoAXs is a collaborative planning tool with a user interface and interactive visualizations. It was developed by a team at MIT to provide an opportunity for stakeholders to examine possible changes to current public transit networks and explore impacts of these changes in a collaborative way. Through several years of evolution, CoAXs is now essentially a front-end interface that receives users' modifications to transit scenarios, requests accessibility calculations from the Conveyal Analysis/R5 back-end, and represents the results in the format of isochrones[4] and related statistics of selected opportunities in catchment areas. Each new CoAXs instance can be built with input of three types of data specific to the context: Open Street Map (OSM) network of the region, General Transit Feed Specification (GTFS) of the transit routes, and georeferenced data of opportunities (e.g., jobs). This section provides a summarized timeline of the evolvement of the tool.

The first version of CoAXs was developed by Anson Stewart in 2014, with the name "IBRT Accessibility", which was defined as a toolkit to foster deliberative participatory inquiry for incremental BRT projects and urban transportation planning (Stewart, 2014). Based on the Open Trip Planner (OTP) platform, which is an open source multimodal trip planning software[5], the tool was developed with two modules – trip planning and analyst. The trip planning module generates suggested routings for a selected origin and destination pair, while the analyst module

[4] An isochrone is a line on a diagram or map connecting points relating to the same time or equal times. In the case of CoAXs, an isochrone represents the area reachable from a given place within a given time constraint on a map.
[5] http://www.opentripplanner.org/

depicts travel time isochrones from a given origin. The tool was tested in a focus group format in the contexts of Boston and Santiago de Chile. The study found that the tool helped make accessibility metrics easily understandable, provided a platform for transportation and land use officials and community advocates to engage in constructive dialogue, and was effective in highlighting the equity implications of accessibility measures (Stewart, 2014).

In 2015, to allow for co-creative transit planning that engages stakeholders to assess different hypothetical transport scenarios, a corridor editor module was developed and added to the tool. It allow users to (de)activate routes and modify frequencies, dwell times, and other service parameters (Stewart & Zegras, 2016). This version of CoAXs was tested in six workshops[6] in Boston's Roxbury neighborhood to examine the potential of CoAXs for encouraging mutual learning about BRT impacts (Stewart, Zegras, Tinn, & Rosenblum, 2018). Using pre- and post-workshop surveys and video recordings, Stewart (2017) found that social learning was enabled by the ability to test and compare accessibility impacts from different locations relevant to different users.

To explicitly test the difference, to CoAXs users, of representing transit scenario benefits in terms of accessibility (isochrones) versus more traditional travel time savings, subsequent development of CoAXs added a point-to-point version showing travel time savings for specific origin-destination pairs. The two versions were tested to examine their differences in fostering shifts from initial expectations of impacts and increasing enthusiasm among users. In October 2016, four workshops were held in Boston in partnership with the LivableStreets Alliance[7]

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[6] In these workshops, CoAXs was tested in parallel with another tool called CityScope, which displayed localized impacts of BRT corridors using 3D models (Cheng, 2016).
[7] LivableStreets Alliance is an advocacy group in the Greater Boston area, see https://www.livablestreets.info/.

exploring impacts of bus priority corridors identified by the Massachusetts Department of Transportation (MassDOT). This study found that users of the accessibility version had greater shifts away from their initial expectations of some impacts, and the accessibility version also helped foster greater focus on others' trips, although the point-to-point version was rated higher in terms of usability (Stewart, 2017).

In 2017, to explore potentials of expanding usage of CoAXs beyond focus group or workshop settings, the team developed a new version that could be used by individuals on their own. This "remote" version (with both accessibility and point-to-point capabilities) had a simplified workflow and self-guided learning modules built in, and was tested in the contexts of Atlanta and New Orleans. Logs of user interactions with tool and survey results suggest that the self-learning process was effective but that the remote version's user-perceived usability and possibility for inspiring imagination were worse than those of the workshop approach (Zheng, 2018).

In June 2017, CoAXs was brought back to the international context of Santiago de Chile, with the addition of accessibility statistics for multiple opportunity types, including jobs, education and health care. Although deployed in workshops, the Santiago instance was developed based on the remote version for its simplicity, using only the accessibility version. The two workshops held in Santiago de Chile revealed that CoAXs was able to improve the engagement process and encourage metropolitan-level discussions among decision makers and stakeholders (Navas Duk, 2017).

3.2 Capabilities Definition for the Pretoria Instance

Based on findings from the preceding studies and the specific context of Pretoria, we selected tool capabilities for the Pretoria instance as described below.

First, the accessibility version was selected over the point-to-point version. In previous experiments, the point-to-point version was rated better in terms of usability, an unsurprising result due of its strong similarities with widely used online trip-planning tools that the users are more familiar with (Stewart, 2017). Nonetheless, the accessibility version had greater impacts on the users in terms of shifting away from their initial expectations and thinking more about others' trips. These impacts are more relevant to our study in Pretoria of changes in user perception and empathy building between different user groups. Moreover, the demonstrated effectiveness of the accessibility version in encouraging higher-level scale discussions (Navas Duk, 2017) also justifies this selection, since helping people have a metropolitan level understanding of the impacts is also an important objective of the Pretoria experiment.

Second, the scenario modification capability for the Pretoria instance primarily focuses on selection of proposed routes. Given the fact that controversies around the proposed routes are mostly about street configuration along the trunk routes and the geographic layout of the feeder routes, we decided it was necessary to allow users to modify scenarios by selecting any combinations of proposed trunk and feeder routes, instead of selecting from a set of pre-defined scenarios. Furthermore, since discussions around the BRT extension have not reached the operational parameters, e.g., headways and dwell times, we opted to not provide the options for modifying these parameters in the Pretoria instance.

Third, for the accessibility representation, we chose to use jobs as the only type of opportunities presented in the Pretoria instance. Since the primary purpose of introducing BRT into the city's public transport system was to provide an affordable alternative for commuting, we considered accessibility to jobs as the most relevant parameter to be represented.

We also explored possibilities of adding other capabilities to the Pretoria instance, but eventually did not include them due to technical and data constraints. First, considering public transport affordability is a serious issue in South Africa, we hoped to add the capability to show cost-constrained isochrones in addition to the time-constrained isochrones from a given origin point. Development of this feature requires: 1) travel cost information accurately built in the input GTFS files, and 2) backend calculation for trips from the given origin point generating a travel cost surface[8] that can be used to generate cost-constrained isochrones. It is easy to build the distance-based fare structure into the GTFS files, however, the backend capability to calculate travel cost surfaces was not developed as of April 2018. Also, since the surroundings of the proposed Line 2B trunk route are more affluent areas, travel cost is not the most pressing concern for the potential users of this particular line. Therefore, development of this capability was not prioritized for the Pretoria instance.

In addition, we would have liked to enable travel time comparisons between private vehicles and the BRT for the Pretoria instance, since this would provide an intuitive visualization of the benefits of BRT on a dedicated bus lane during peak hour congestions. Nonetheless, development of this capability would require: 1) simulated or surveyed automobile travel time matrices for the region, and 2) the capability to calculate isochrones on the basis of these travel

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[8] A travel cost surface is a raster of travel costs from the selected origin to the rest of the region. Current generation of time-constrained isochrones are based on travel time surfaces calculated at the Conveyal Analysis back-end.

time matrices. Currently, the isochrones from a given origin are calculated from a series of binary regular grids, which are generated from the travel time surface[9] for a given origin. Each binary regular grid represents whether a point can be reached or not within a given time constraint from the origin.[10] The isochrone calculation from a binary regular grid is performed on the front-end[11], and the conversion from travel time matrices to travel time surfaces and corresponding regular grids is fairly easy in terms of programming. Therefore, travel time matrices can be converted to binary regular grids separately, and these regular grids can be loaded directly on the front-end, to achieve fast calculation of private vehicle isochrones on-the-fly. However, development of this feature was constrained by the fact that auto travel time matrices during peak hours were not available.

3.3 Development and Adaptation for the Pretoria Instance

3.3.1 Scenarios Definition

As introduced in Subsection 1.1.2, two scenarios for the Line 2B trunk route are under consideration – BRT operations in mixed traffic or on additional dedicated bus lane. In addition, we have a baseline, status quo, scenario, i.e., no Line 2B (Figure 2).

[9] A travel time surface is a raster of travel times from the selected origin to the rest of the region, see http://docs.analysis.conveyal.com/en/dev/analysis/.

[10] Imagine a series of planes cutting through a surface, generating areas on the plane that are either covered under the surface or exposed.

[11] An isochrone is generated from a binary regular grid using a front-end package called jsolines, see https://github.com/conveyal/jsolines.

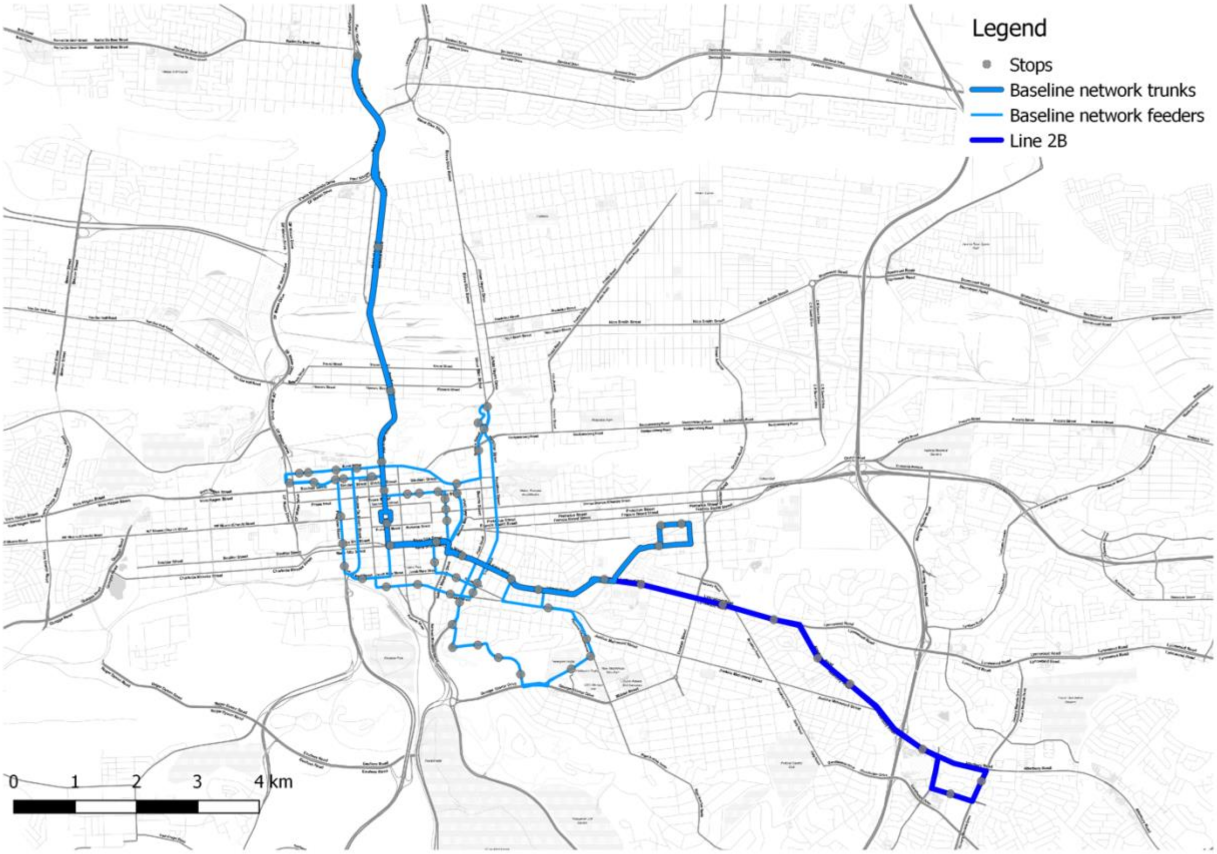
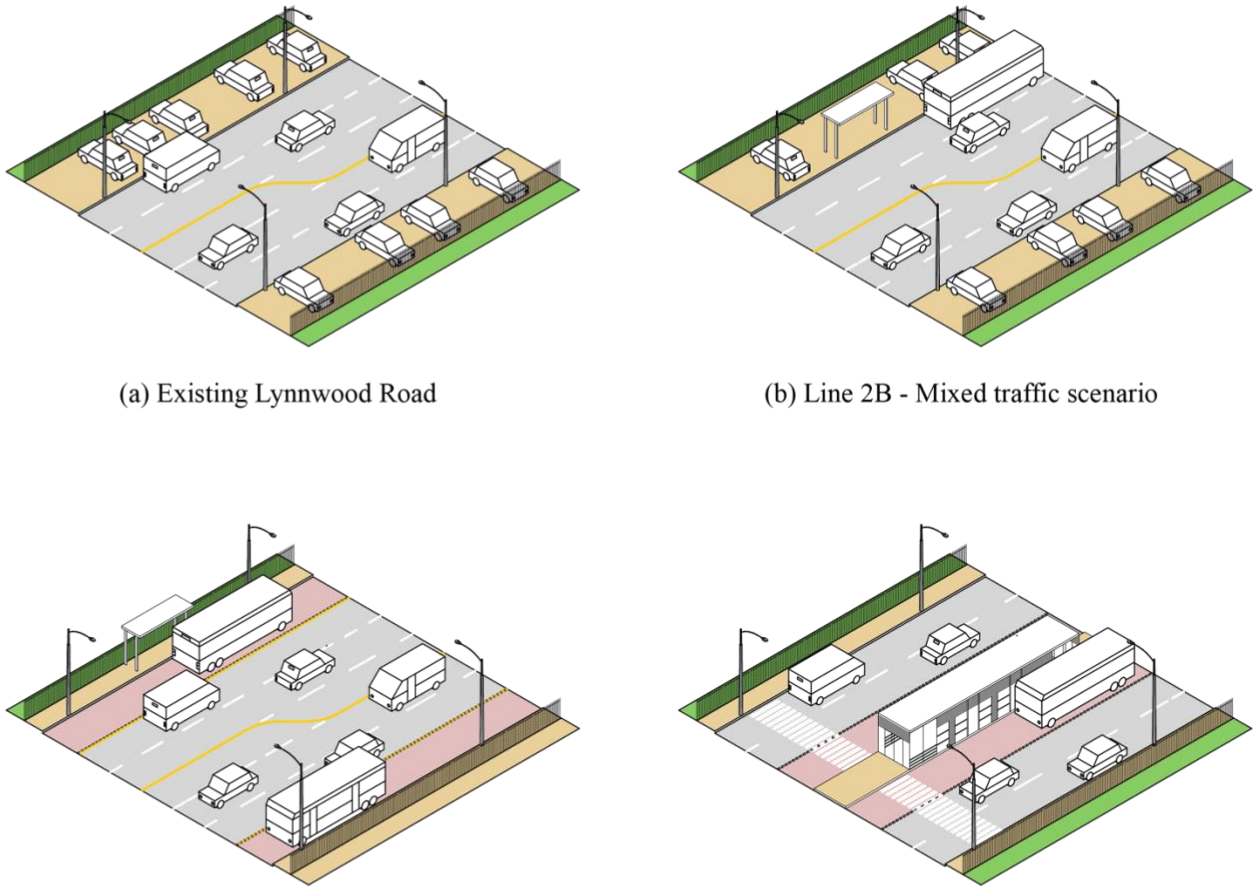


Figure 2: Map of baseline scenario and Line 2B trunk route

Figure 3 illustrates the street configurations of the trunk route scenarios along Lynnwood Road. The current street consists of two general traffic lanes in each direction, and a shared turning lane in the middle, with parking on sidewalks. For the mixed traffic scenario of the Line 2B addition, parking spaces will be removed at places where BRT stations need to be located, and buses will travel on the general traffic lanes with all other vehicles. For the dedicated bus lane scenario, parking spaces on each side will be removed while the sidewalk will remain, and a bus lane dedicated to the BRT and separated from general traffic lanes by barriers will be added. There are two options for the dedicated bus lane addition: 1) the bus lane located along the sidewalk of each direction, with open bus stations located on the sidewalks; 2) the bus lane located on the center side of each direction, with closed bus stations located on the median.



(a) Existing Lynnwood Road

(b) Line 2B - Mixed traffic scenario

(c) Line 2B - Dedicated lane scenario (option 1)

(d) Line 2B - Dedicated lane scenario (option 2)

Figure 3: Schematics of trunk route scenarios

Beyond the two possible street configuration scenarios for the Line 2B trunk route, interest in exploring possible feeder routes for Line 2B was also raised in discussion between the local CoAXs team and city officials. Subsequently, the local team created six hypothetical feeder routes based on their knowledge of the surrounding neighborhoods and the existing feeder routes for Lines 1A and 2A (Figure 4).

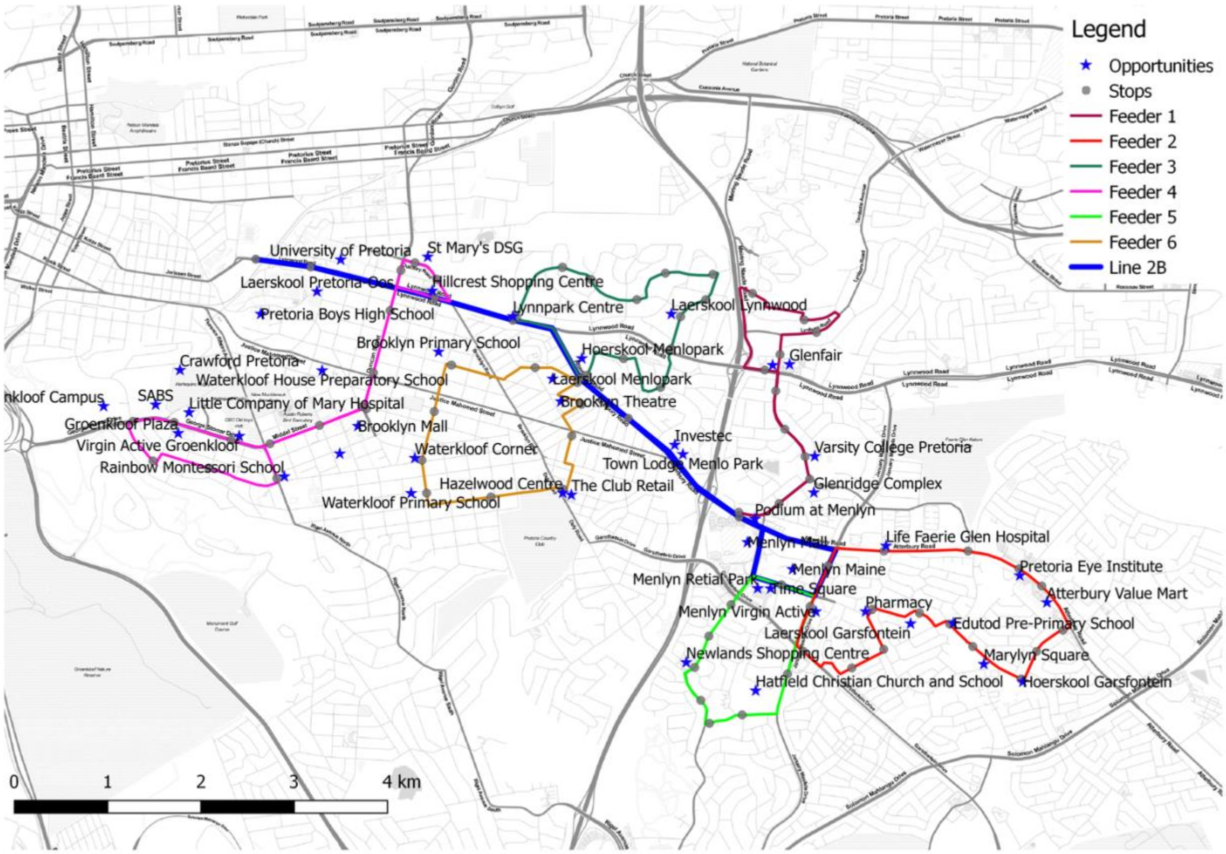


Figure 4: Map of hypothetical feeder routes and places of interest in context

For the Pretoria instance of CoAXs, we allow users to select any combination of the six feeder routes as long as either of the Line 2B trunk route scenarios is selected. In each case, the number of scenarios of feeder route combination n can be calculated as

$$n = \sum_{r=0}^{6} \binom{6}{r} = 2^6 = 64$$

Since there are two trunk route scenarios with Line 2B, in addition to a baseline scenario, the total number of scenarios N is

$$N = 2n + 1 = 129$$

Table 1 summarizes the scenarios.

Table 1: Summary of scenarios

Trunk Route Scenario	Feeder Route Scenario	Number of Scenarios
No Line 2B	No feeders	1
Line 2B – mixed traffic	All combination of 6 feeders	64
Line 2B – dedicated bus lane	All combination of 6 feeders	64

3.3.2 Route Specifications and Assumptions

For simplicity and clarity, we made the following assumptions when defining route specifications. First, since the benefits of a BRT operating on a dedicated lane are most evident when traffic is most congested, we make all the calculations based on travel speeds during morning peak hours, which is from 6am to 9am on weekdays. Second, since travel time matrices for the surrounding area of proposed Line 2B was not available, and the capacity and travel demand of Lynnwood Road are comparable to those of the roads where Line 1A and Line 2A operate, we assume that the average travel speed of BRT in the dedicated bus lane scenario is similar to the average travel speeds of Line 1A and Line 2B. Third, for the feeder routes and the mixed traffic scenario of the trunk route, we assume that the BRT travel speeds are similar to the travel speeds of the existing feeder routes for Line 1A and Line 2A. Fourth, we assume that the morning peak frequencies of the proposed trunk route and feeder route buses are the same as those of the existing ones.

Using actual operational records from March 2016 for Line 2A, we calculated the morning peak hours average speed as 25 km/h. Using timetables of the existing feeder routes for Line 1A and

Line 2A, we calculated the average speed as 15 km/h. Table 2 lists specifications of the existing routes in the baseline scenario based on morning peak timetables.

Table 2: Specifications of baseline routes

Route	Description	Speed (km/h)	Number of Stops	Dwell Time (seconds)	Headway (minutes)
Line1A	Trunk between CBD and Pretoria North	25	11	30	7
Line2A	Trunk between Molefe Makinta Station and General M. Siyothula Station	25	19	30	7
Existing Feeder1	Feeder between Ruth Mompati Station and Steve Biko Hospital	15	11	30	7
Existing Feeder4	Feeder route between Mahatma Gandhi Station and TUKS Groenkloof	15	15	30	7
Existing Feeder5	Feeder between Nana Sita Station and Belle Ombre	15	23	30	7
Existing Feeder6	Another feeder route between Nana Sita Stn and Belle Ombre	15	25	30	7
Existing Feeder7	Another feeder between Mahatma Gandhi Station and TUKS Groenkloof	15	13	30	7

Based on the aforementioned assumptions, Table 3 provides the specifications for the proposed trunk and feeder route scenarios.

Table 3: Specifications of proposed routes

Route	Description	Speed (km/h)	Number of Stops	Dwell Time (seconds)	Headway (minutes)
Line2B Mixed Traffic	Trunk between Hatfield and Menlyn. Operating in mixed traffic.	15	16	30	7
Line2B Dedicated Lane	Trunk between Hatfield and Menlyn. Operating in a dedicated bus lane.	25	16	30	7
Line2B Feeder1	Feeder from Menlyn to Lynburn Road	15	11	30	15
Line2B Feeder2	Feeder down Atterbury Road	15	15	30	15
Line2B Feeder3	Feeder in Lynnwood on King's Highway	15	12	30	15
Line2B Feeder4	Feeder between Hatfield and Brooklyn	15	16	30	15
Line2B Feeder5	Feeder between Menlyn and Newlands	15	9	30	15
Line2B Feeder6	Feeder at Menlo Park	15	10	30	15

3.3.3 Data Requirements and Preparation

As introduced in Section 3.1, each new CoAXs instance requires three types of data for the specific context to be developed: the OSM network for the region, the GTFS for the transit routes, and georeferenced data of opportunities.

OSM provides open source georeferenced data around the world, including road and walking path networks. The OSM extract of the Greater Pretoria region is available for download in Protocolbuffer Binary Format (PBF), which is readable by Conveyal for back-end calculations.

GTFS information for Pretoria is not available from the city or the transit agency. Therefore, for the purpose of this experiment, we created the GTFS feeds of the existing and proposed BRT routes with GTFS Editor, using the specifications in Table 2 and Table 3. The georeferenced geometries and stops of the proposed trunk route are drawn based on the public proposals, and those of the proposed feeder routes are drawn based on the local team's hypothetical proposal.

For the Pretoria instance, the opportunity data refer to Geographic Information Systems (GIS) data of job locations in the region. We obtained the data in shapefile format from the Council for Scientific and Industrial Research (CSIR) of South Africa. This dataset represents number of jobs in the 243 Transport Analysis Zones (TAZs) of Tshwane in 2014. It includes jobs in sectors of retail, office, industrial, commercial, local services, agriculture and mining, construction, transport, domestic workers, and others. For this experiment, we use the total number of jobs for the calculation. Figure 5 shows the distribution of total number of jobs across TAZs in Tshwane (divided into quantiles).

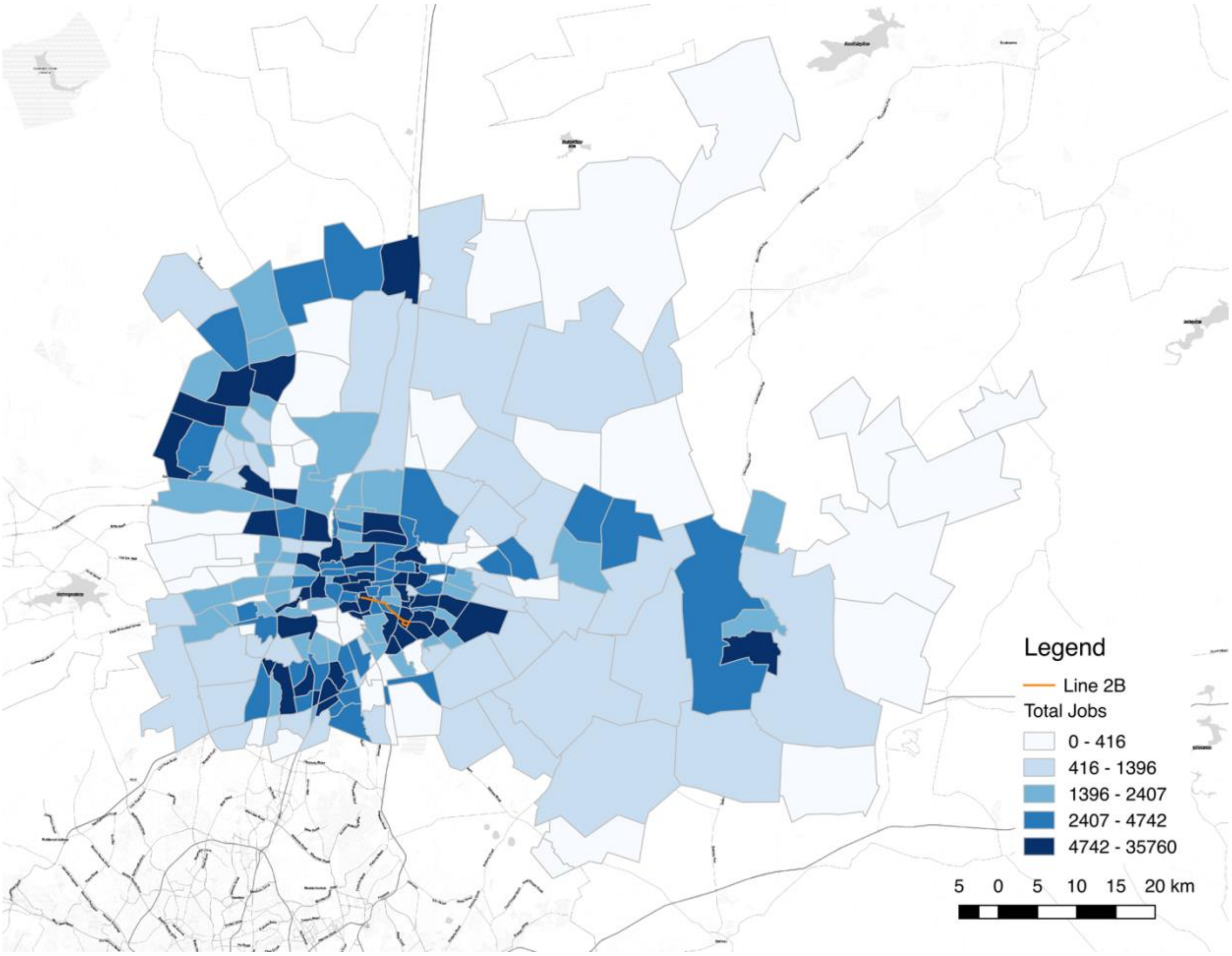


Figure 5: Choropleth map of total number of jobs in Tshwane by TAZ

3.3.4 Back-end Configuration

Development of the Pretoria instance involved back-end configurations made through Conveyal Analysis UI, which is Conveyal's front-end for creating and modifying scenarios.[12] With the three types of data uploaded, we created two scenarios in Conveyal Analysis, referred to as Scenario 1 and Scenario 2. Scenario 1 represents the baseline scenario described in Subsection 3.3.1, i.e., without Line 2B or feeders. Scenario 2 is the new scenario that users can modify and compare with the baseline scenario.

[12] https://github.com/conveyal/analysis-ui

We also created a series of eight modifications in Conveyal Analysis, each removing one of the proposed routes – Line 2B trunk mixed traffic, Line 2B trunk dedicated lane, and each of the six Line 2B feeders. By default, all modifications are active in both scenarios, so that both scenarios on the front-end represent the baseline scenario upon initial loading of each session. Through users' interactions on the CoAXs front-end, all modifications remain active in Scenario 1, and get toggled between active and inactive in Scenario 2. Therefore, Scenario 1 always represents the baseline scenario, while Scenario 2 gets modified with routes selected by users.

3.3.5 Front-end Modification

We used the CoAXs "remote" version as the basis of the front-end development, due to its simplified workflow and updated framework.[13] Through tests with local internal users, three types of modifications were made to develop the front-end for the Pretoria instance. First, to make it suitable for a workshop setting, the landing page with tutorial videos, step-by-step guidance, and built-in surveys were removed. Second, to make the interface specific to the structure of the scenarios, the Service Editor panel was updated to allow for multiple selection of feeder routes only when one of the two trunk route scenarios is selected. Third, to help users find locations on the map, major points of interest, such as landmarks, institutions, public amenities, etc., were added to the map. In addition, due to back-end upgrades made by Conveyal, requests to the back-end with modified scenarios were made through Application Programming Interface (API) calls, a more common and formalized way to integrate the front-end and back-end. Figure 6 shows a screenshot of the CoAXs Pretoria interface.

[13] The "remote" version was redeveloped with React.js.

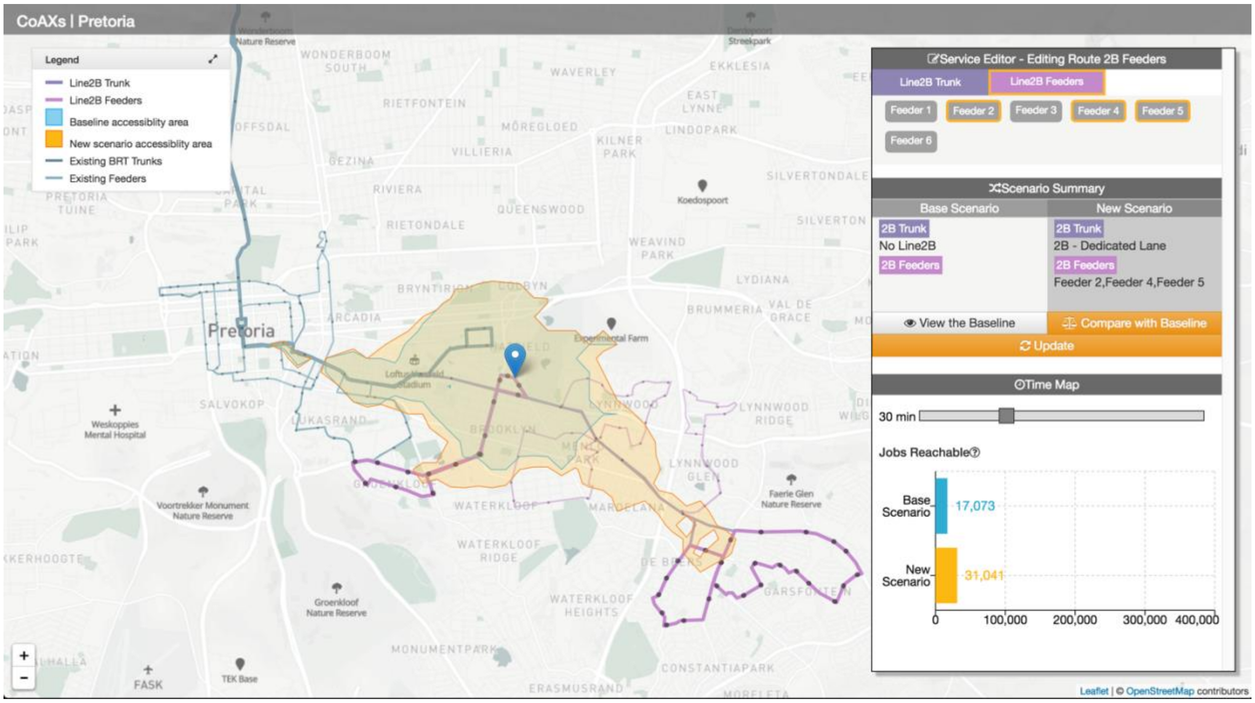


Figure 6: Screenshot of CoAXs Pretoria

The interface for the Pretoria instance remains similar to the previous “remote” version, with a map as the main component that has a movable pin representing the user-selected origin point of isochrones. A panel on the right-hand side has a scenario editing area, a scenario summary table, a slider for setting the time constraint, and a bar chart area showing the scenario results in accessibility statistics (from top to bottom in Figure 6). The isochrones are recalculated either when a user clicks the “Update” button or moves the origin pin.

Chapter 4: Experiment Design

With the CoAXs instance developed specifically for the Pretoria context as described in the preceding chapter, four workshops with local residents were held in July 2018, in partnership with the University of Pretoria. These workshops were designed drawing from the experiences of previous workshops in Boston and Santiago de Chile, with modifications according to the Pretoria context. This chapter provides detailed information on how these workshops were organized, including general information (Section 4.1), workshop activities (Section 4.2), and data collection methods (Section 4.3)

4.1 Workshops Overview

Some of the general arrangements of the workshops were the same across all four workshops, while some varied. These arrangements are introduced in the following subsections.

4.1.1 Common Arrangements: Scheduling, Staff, and Setup

In terms of scheduling, the four workshops were scheduled on evenings of four separate weekdays over two weeks – two in the first week and two in the second week. Each workshop took approximately three hours, following the same agenda (Table 4) that will be discussed in detail in Section 4.2.

All four workshops had similar staff arrangements, including two presenters introducing the tool and background information, two facilitators for the discussion session, and two other staff members in charge of reception, room setup, food, survey distribution and collection, etc. The two presenters were also present at the scenario analysis session to provide guidance for user interaction with the tool. The facilitators were doctoral students recruited from the sociology department at the University of Pretoria, so that facilitation during the discussion session was provided by an impartial third-party.

Table 4: Workshop agenda and staff arrangement

Time	Activity	Staff in Charge
17:00 – 17:10	Welcome and opening remarks	Professor Venter (University of Pretoria)
17:10 – 17:30	Introduction to CoAXs and scenarios	Presenters (2)
17:30 – 17:45	Pre-workshop surveys	General staff (2)
17: 45 – 18:45	Scenario analysis using CoAXs by participants	Presenters (2)
18:45 – 19:00	Refreshments	General staff (2)
19:00 – 19:30	Facilitated discussion about CoAXs and BRT	Facilitators (2)
19:30 – 19:45	Post-workshop surveys	General staff (2)
19:45 – 19:50	Closing remarks	

As for room setup, in each workshop, a 60-inch touch screen was used for group interaction with the tool. The touch screen was placed in a vertical position so that all participants around it could see the contents well. In the last two workshops, an additional option of individual interaction with the tool on a laptop was provided.[14] Participant seating was arranged in a row of table and chairs in an enclosing format facing the touch screen, which was also used for the presentation. The participants were asked to leave their seats and gather around the screen during the scenario

[14] This option was not provided in the first two workshops because the internet bandwidth at the venue of the first two workshops did not allow for multiple instances running simultaneously, which was an unexpected practical constraint.

analysis session. Figure 7 shows the setup at the first workshop, including seating layout during presentation (left) and scenario analysis session at the touch screen (right).

Figure 7: Workshop setup

4.1.2 Arrangements Specific to User Groups: Venues and Participant Recruitment

To test the research questions and hypotheses in Section 1.2, the workshops targeted two main groups of participants: 1) residents in the surrounding neighborhoods of the Line 2B trunk route, who are mostly private vehicle users; and, 2) students and young professionals in the surrounding area, who are mostly public transport users. The first two workshop targeted the first group, and the last two targeted the second group. Therefore, the two sets of workshops took place at different venues and used different participant recruitment channels.

Venues for both sets of workshops were community churches. The first two workshops took place in a residential neighborhood closer to the Menlyn end of Line 2B trunk, while the last two took place in the student area in Hatfield close to University of Pretoria (Figure 8). Participants at the first two workshops were recruited primarily through emails and social media messages[15] sent to over 7,000 residents in Ward 82 (highlighted in Figure 8) by the Ward councilor. Participant recruitment for the last two workshops was mostly through emails from the local team to university students and recent graduates, as well as posters on the university campus.

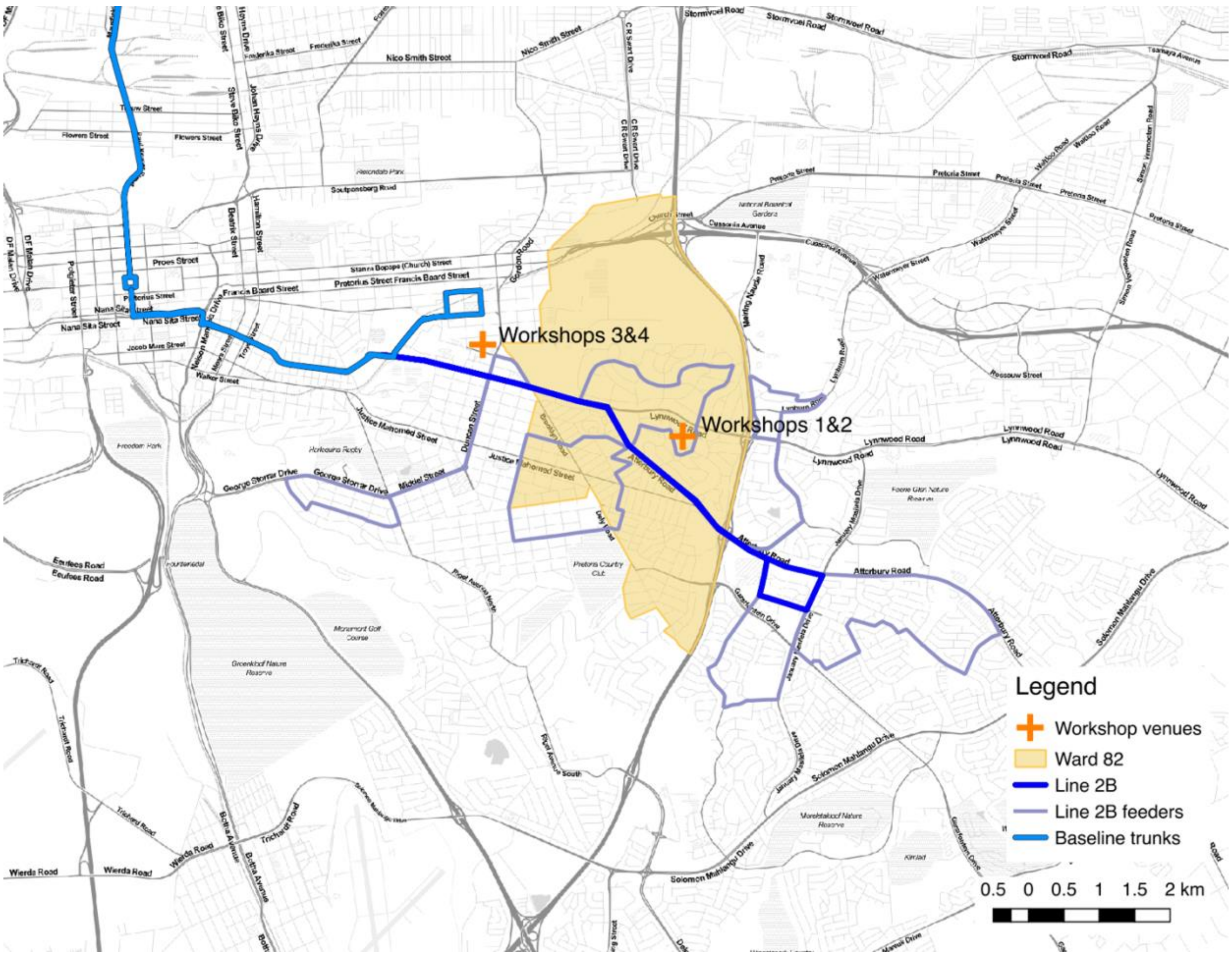


Figure 8: Map of workshop venues and Ward 82

[15] Includes messages to WhatsApp groups and Facebook groups of the ward members.

4.2 Workshop Process

As introduced in the preceding section, all workshops followed the agenda presented in Table 4. This section provides details of each step in the workshops, except for the pre- and post-workshop surveys, which will be described in detail in the next section (Section 4.3)

Upon arrival at the workshop venue, each participant was given an information package. The package contained a consent form to participate in the experiment, the workshop agenda, an information sheet (Appendix A: Information Sheet) with explanations of key transport terms, and two maps showing the Line 2B trunk route in the city and the proposed feeder routes in the local context.

The introduction presentation consisted of two parts – an introduction to CoAXs and an introduction to the background and scenarios. The introduction to CoAXs gave a high-level overview of the software structure, data inputs, and experiments in other contexts, and clarified terms such as “isochrone” and “travel time.” The background introduction summarized the story of the Line 2B trunk route proposals and contentions, and explained the specifications of the scenarios under discussion.

After the pre-workshop surveys, the participants were asked to gather around the touch screen, and one of the presenters gave a brief demonstration of interacting with the tool. Then the participants were free to modify the scenarios and move the origin point and discuss the results. The presenters remain present only to make sure all participants have a chance to use the tool, and prompt the participants to explore accessibility from their home or work locations when necessary. As explained in the preceding section, an option to use the tool on a laptop was provided in the last two workshops during this session. This scenario analysis session lasted for about one hour.

Then, after a short food break, the participants return to their seats for the facilitated discussion session. The facilitators guide the discussion along a sequence of four topics: experience of using CoAXs, overall experience of the workshop, opinions on the proposed projects, and opinions on public participation in issues related to transport planning. The topics are designed to get broader through the discussion, because from the first workshop, we learned that it is a natural tendency for people to bring up broader related issues when discussing a specific topic, which makes it difficult to narrow down a discussion from a broad topic. The facilitators are also responsible for getting all participants involved in the discussion.

In general, the workshops typically took less than three hours. Some participants also stayed after the activities were finished and continued discussion with the team.

4.3 Data Collection

Two types of data collection methods were designed and implemented in the Pretoria experiments: quantitative data from pre- and post-workshop surveys and qualitative data from workshop observations and facilitated discussions.

The pre- and post-workshop surveys are included in the Appendices for reference. Questions in the surveys were designed to capture participants' perceptions and attitudes in the following aspects before and after using the tool:

- Understanding of the public transport projects being discussed;
- Understanding of priorities in public transport planning;

- Perceived importance of opportunities in measuring accessibility;
- Expected impacts of proposed public transport projects, with questions specific to each trunk route scenario; and,
- Attitudes to the proposed public transport projects and enthusiasm in using or advocating for them.

The pre-workshop survey also collected participants' basic information, including occupation, education and income level, commute modes, and experience with public meetings. The post-workshop survey asked participants to evaluate the usability of CoAXs and its usefulness for public participation in transport planning. The pre-workshop surveys were collected immediately after participants completed them, to prevent participants from referring to their previous responses when completing the post-workshop surveys.

Qualitative data collection during workshop discussions focused on participants' feedback on the scenarios and feedback on the tool and the workshop, in comparison with traditional public meetings regarding similar issues. Follow-up interviews were also carried out with two of the participants, a ward councilor and a city official, to obtain more detailed information on traditional public meetings.

Chapter 5: Experiment Results

5.1 Participant General Information

The four workshops recruited 33 participants in total. Among these, 31 provided valid survey responses. Based on responses to the question “How often do you use the following modes to travel between home and work on a daily basis or to complete your most frequent trip?”, participants can be divided into two categories: car users and non-car users. Specifically, if a participant identified “car (as driver or passenger)” as her most frequent mode of commute, she is categorized as a car user, otherwise, if any of the other modes is the most frequently used, she is categorized as a non-car user. Table 5 summarizes the numbers of participants, valid survey responses, and car users/non-car users from each workshop. As expected, participants at the first two workshops were mostly car users, while the majority of participants at the last two were non-car users.

Table 5: Summary of workshop participants and user groups

Workshop	Participants	Valid responses	Car users	Non-car users
1	7	7	6	1
2	4	4	4	0
3	11	10	3	7
4	11	10	2	8
Total	**33**	**31**	**15**	**16**

Other factors that might affect the participant discussions also differ across the two groups, such as education levels, spending on transport, and previous experiences with public participation events related to planning issues.

First, the car users have higher education levels than the non-car user group. As shown in Figure 1, most car users hold a higher education degree, while most non-car users have only completed Grade 12 education. This is expected because the second two workshops mainly targeted university students, and most participants were undergraduate students, and only one of the high school graduates was not completing a college degree. As a result, during the workshops no education-related communication or discussion difficulties were observed.

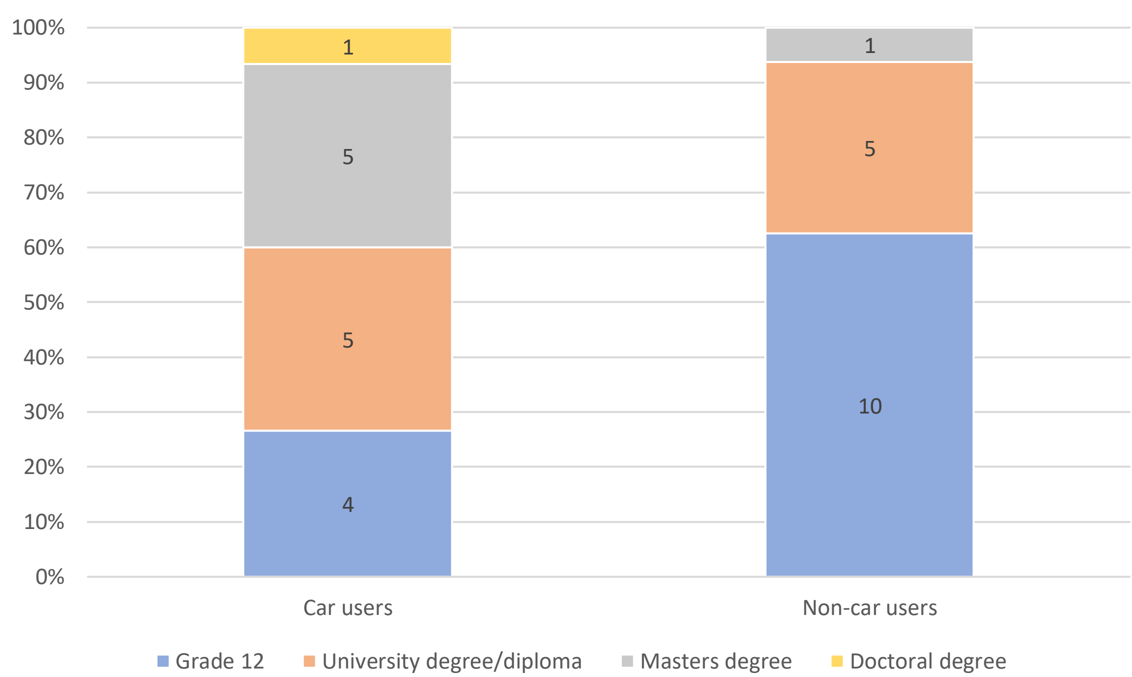


Figure 9: Education levels of car users and non-car users

Second, as expected, the car users have much higher reported monthly spending on transport than the non-car users, even though the reported expenses do not include costs related to buying a car. As shown in Figure 10, only one non-car user reached the average spending among all respondents. Corresponding to this disparity, in the tool interaction and discussion sessions, car users tend to talk about travel time savings as their main motivation of considering taking the BRT, while the topic of lower travel costs comes up more often in comparing BRT with minibus taxis among the students.

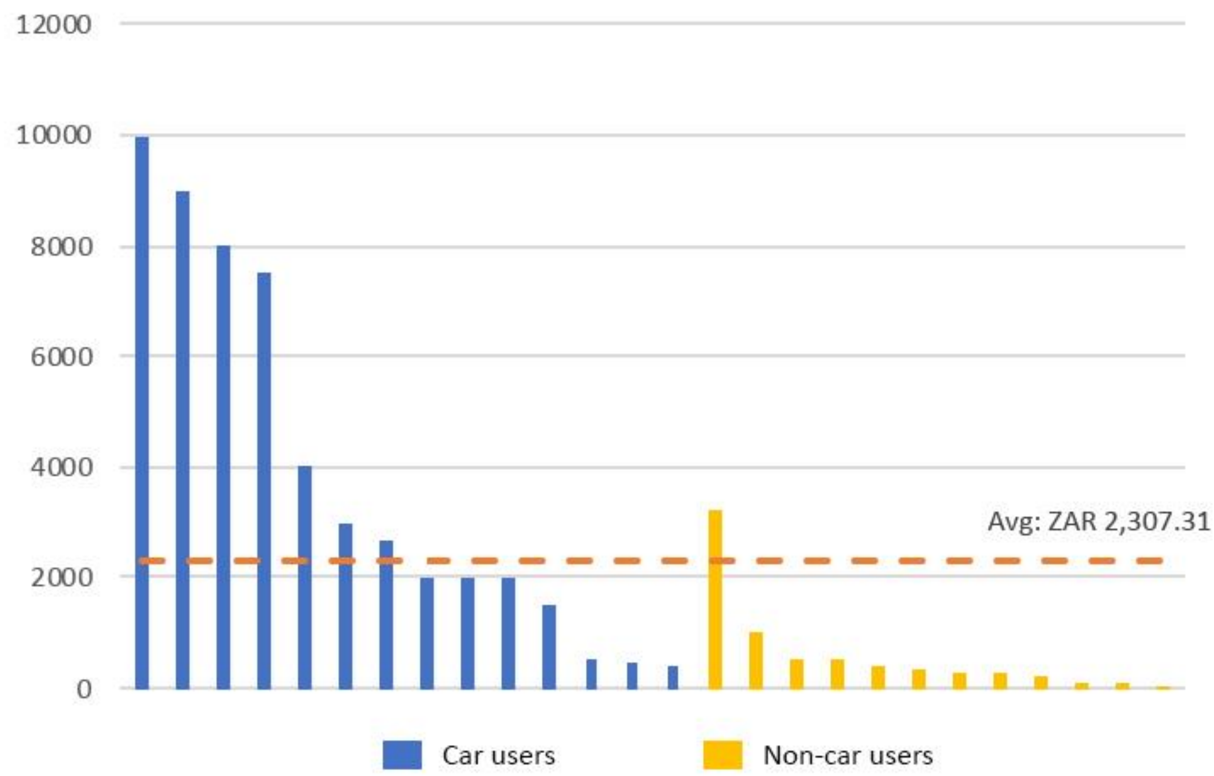


Figure 10: Reported monthly transport spending by car users and non-car users

Third, the car users have attended more public meetings on planning-related issues than the non-car users. As shown in Figure 11, most non-car users have not participated in any public planning meetings over the past year, while most car users have participated in multiple meetings over the past year. Most participants in the first two workshops either work in related fields or are activists who often go to public meetings; students, on the other hand, in the last two workshops, are not familiar with the public meetings. As a result, the topic of how CoAXs can be helpful in future public meetings was more discussed in the first two workshops than in the last two.

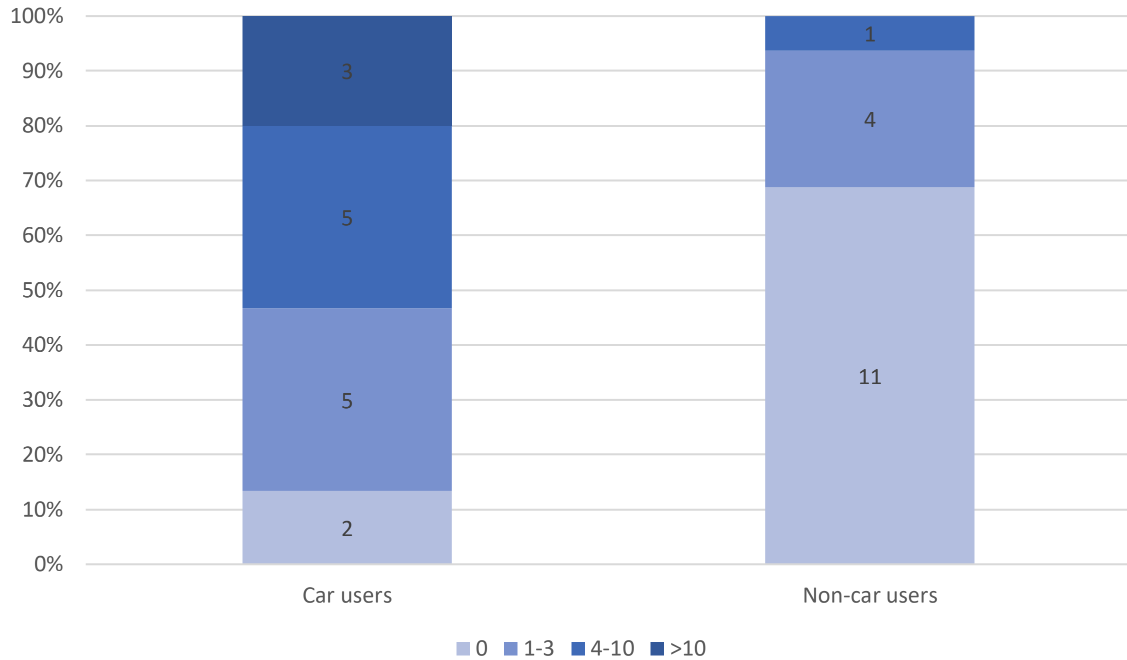


Figure 11: Number of public planning meetings attended in the past year by user groups

5.2 Tool Interaction and Discussion

5.2.1 Tool Interaction Observation

In all four workshops, facilitators ensured that every participant interacted with CoAXs. The tool interaction sessions took different forms between the first two and last two workshops. In the first two workshops, the tool interaction sessions were mostly with all participants gathering around the touch screen, with each participant taking turns to step up to the screen and make scenario modifications and discuss the resulting isochrones with the group. In contrast, in the last two workshops, participants were invited to the touch screen, but they formed smaller groups of 2-4. Each of these groups took turns to interact with CoAXs on the screen and discuss within the group, while the other groups had separate discussions around the screen. One factor that could possibly contribute to the different group dynamics is the difference in previous public meeting experiences among the participants. Since participants in the last two workshops had much less experience with public meetings of big groups, they may have felt more comfortable with clustering and discussing with their friends. Another possible contributing factor relates to a suggestion that came up in the discussion session in the last two workshops - that CoAXs can be developed into an end-user mobile app similar to a navigation app. This suggestion implies that the participants imagined usage of the tool to be more personal and individual rather than in a large group setting.

In the last two workshops, with the laptop version of CoAXs available, some users preferred the laptop to the touch screen. One and four participants used the laptop version in the third and fourth workshops, respectively. None of the laptop users also used the touch screen version and almost all of the laptop users chose to use the laptop immediately after the option was announced. In the fourth workshop, the four laptop users interacted with the tool and discussed as a group, instead of individually. Even in the third workshop, where there was only one laptop user, he was constantly discussing with facilitating staff instead of using the tool on his own. In follow-up interviews with two of the laptop users, both indicated that the reason they preferred the laptop version was they did not feel comfortable enough to explore scenarios on the tool in front of a big crowd.

5.2.2 Discussion Summary and Observation

Table 6 summarizes participants' feedback on the projects from the facilitated discussion sessions in each workshop. All participants in all workshops agreed that the proposed BRT route is not located to reach the neighborhoods most in need. Specifically, participants identified the townships, such as Soshanguve and Mamelodi, to be the areas that will benefit the most from BRT as an affordable commuting service (refer to Figure 1). Comparing feedback from different workshops, participants in the first two workshops focused more on broader issues related to impacts of the additional BRT route, such as densification and congestion. Discussions during the last two workshops focused more on the characteristics of the additional BRT route, such as frequency and bus types. Again, this difference likely relates to the different participant demographics. Participants in the first two workshops had more previous understanding of the projects and some have been involved in the Line 2B debate for years and are familiar with transport planning topics. In contrast, most participants at the last two workshops did not have prior knowledge of the project, or transportation planning in general, therefore, their discussions were mostly from the perspective of a user. Specifically, although the issue of fares was brought up in all workshops, it was only discussed in depth in Workshop 4, where the participants expressed concerns of increased travel costs when transferring from other modes without fare integration.

Table 6: Summarized participant feedback on the discussed projects

Workshop	Feedback on the Projects
All four workshops	The BRT system misses the point in that it does not cater to the marginalized working class that is in much more need for public transportation. Instead, it caters for people that already enjoy the privilege of private transport.
Workshops 1&2	Potential densification along the trunk route will be a concern of people living in those areas.
Workshop 1	Line 2B is located away from the much busier routes with greater need.
	It would be more beneficial to the city to incorporate and/or improve the existing transport network rather than introducing a new BRT system.
Workshop 2	Resistance from the taxi industry is a big challenge to the success of BRT.
	Addition of Line 2B trunk route will lead to congestion if there is no dedicated bus lane.
Workshop 3	The BRT system needs to improve frequency and speed on the trunk lines.
Workshop 4	Comfort of the buses will be key to attracting motorists to leave their private cars and switch to the BRT.
	Integration with existing public transport networks will not be effective unless ticketing and fares are well integrated.

Table 7 summarizes the feedback on CoAXs and the workshops. Participants in all four workshops agreed that CoAXs is helpful in a public consultation setting for decision-making. Other common feedback across all workshops included suggestions for broader participant involvement and additional tool features, such as integration with other transit modes and cost-constrained accessibility. Because participants in the first two workshops had more experience with public meetings among, their feedback focused on how to improve public meetings for better participation results. Since the participants in the last two workshops were younger and more proficient with digital technology, their feedback included suggestions of adding more features to make CoAXs an app for more general use.

Table 7: Summarized participant feedback on CoAXs and workshop

Workshop	Feedback on CoAXs and Workshop
All four workshops	Appreciated the tool being helpful in a public consultation setting for decision-making.
	The tool needs to be made available to a wider audience, especially working class in the townships who will benefit the most from BRT.
	It would be helpful to see scenarios where BRT is integrated with existing public transport systems, with cost constraints.
Workshops 1&2	Better marketing and advertising are key to improving attendance to these workshops.
	Public meetings usually attract people with complaints only.
Workshops 3&4	The visualizations could be enhanced if 3D, satellite & street view, and more graphs are incorporated.
	The workshop helped clarify the BRT scenarios, and improve knowledge on transport related issues in planning.
Workshop 1	Appreciated that the tool not only focuses on transport but also socioeconomic activities.
Workshop 2	It would be helpful to show direct comparison between isochrones in the dedicated bus lane scenario vs. mixed traffic scenario.
	The tool would be of better use if it is incorporated earlier in the decision-making stage.
Workshop 3	CoAXs could be developed into an end-user mobile app, showing areas accessible from users' locations, different from existing point-to-point navigation apps.
	Real-time bus location and information could be incorporated in the app.
Workshop 4	User interface needs to be simpler for general users to get started quickly.

5.3 Survey Results Analysis

The survey responses are analyzed in four main topics: project understanding, expected project impacts, user attitudes and enthusiasm, and tool usefulness and usability. Questions in the survey for the four topics are all choice questions using a five-point Likert scale, where 1 means strongly disagree with the provided statement or "very negative impact" for the specified group or scope, and 5 means strongly agree or "very positive impact" (see Appendices).

For the first three topics, the pre- and post-workshop surveys have repeated questions, which allows us to examine shifts in participant responses as a measurement of effectiveness of the workshops. Tilted line-segment plots and tabulated percentages of participants in different shift categories (i.e., positively shift, no shift, and negative shift) are used to represent shifts in the responses to these questions. The Wilcoxon signed-rank test is also used to test the null hypothesis that the median response did not shift. This test is more appropriate than a traditional *t*-test when comparing distributions from the same sample with a small sample size; it does not require the assumption of a normal distribution.

For the topics of expected project impacts and enthusiasm, shifts in responses for car users and non-car users are also examined separately using the same techniques described above. In addition, differences in responses between the two groups are also tested and compared. Mann-Whitney *U* tests are used to test the null hypotheses that the distributions of the pre-workshop scores are identical between the two user groups, and the distributions of post-workshop scores are identical between the two user groups. Then the results from the pre- and post-workshop tests are compared. A significant *p*-value from pre-workshop scores and an insignificant *p*-value from post-workshop scores would suggest that participants came in with different expectations or attitudes, but had similar expectations or attitudes after the workshop. An insignificant *p*-value from the pre-workshop scores and a significant *p*-value from post-workshop scores would suggest that participants came in with identical distribution of scores, but had significantly different expectations or attitudes after the workshop.

5.3.1 Project Understanding

	I know the public transport projects presented.	I can describe the features…	I can describe the impacts…	I have enough knowledge to advocate…
Average score (pre)	4.18	3.89	3.93	3.68
Average score (post)	4.50	4.21	4.07	4.07
Shift	0.32	0.32	0.14	0.39
Positive shift	32%	32%	32%	39%
No shift	61%	61%	50%	50%
Negative shift	7%	7%	18%	11%
p-value (Wilcoxon)	0.03301	0.03301	0.4905	0.02364

Figure 12: Shifts in project understanding

Figure 12 shows the score shifts by all respondents to the four questions about project understanding. All four questions receive increased average scores after the workshop, although the improvement in being able to "describe the impacts" is not statistically significant. For all questions, the majority of participants have no shift in their responses, and among the participants who have shifted scores, more of them have positive shifts. These results suggest that CoAXs is effective in improving participants' general understanding of the projects, knowledge of the project features, and knowledge to advocate for or against the projects.

5.3.2 Expected Project Impacts

Participants' expectations about project impacts are measured by the question: "what impact do you think the two scenarios of expanding *A Re Yeng* between Hatfield and Menlyn will have on the following individuals or groups?" Participants were asked to provide their answers to the question specific for nine groups (or individuals) in each trunk route scenario (i.e., dedicated lane and mixed traffic). Overall score comparison and shifts among all respondents are first analyzed, then scores and shifts from the two user groups are compared.

5.3.2.1 Expected Project Impacts among All Participants

To begin with, Table 8 summarizes the average scores for answers to the questions about participants' expectations about project impacts across different groups in both the pre- and post-workshop surveys. Before and after using CoAXs, participants generally had significantly positive expectations about impacts on themselves, their neighborhoods, other neighborhoods, the city, pedestrians, public transport users, and people with disabilities. As expected, in both surveys and in both scenarios, participants had the most negative expectation of impacts on private vehicle users. In the dedicated lane scenario, participants had the most positive expectation of impacts on public transport users, both before and after using CoAXs.

Table 8: Summary of Average score for impacts of two trunk line scenarios

	Pre-workshop			Post-workshop		
	Dedicated lane	Mixed traffic	*difference*	Dedicated lane	Mixed traffic	*difference*
Yourself	3.692	2.692	*	3.731	2.885	*
Your neighborhood	3.462	2.808	*	3.731	2.885	*
Other neighborhoods	3.308	2.808	*	3.885	3.000	*
Your city	3.800	2.880	*	4.200	2.800	*
Pedestrians	3.500	2.893	*	3.679	3.071	*
Cyclists	2.778	2.815		3.222	2.852	
Private vehicle users	2.571	2.500		2.964	2.536	
Public transport users	4.357	3.393	*	4.393	3.179	*
People with disabilities	4.074	3.185	*	4.074	3.370	*

Note: "difference" column represents whether the difference between the two scenarios (dedicated lane versus mixed traffic) is statistically (*) significant ($\alpha = 0.05$) using a Wilcoxon signed-rank test.

While participants generally had positive expectations about the impacts on different groups of people, these expectations did not change after the workshop. Specifically, Figure 13 and Figure 14 illustrate the shifts specific to the dedicated lane scenario and the mixed traffic scenario, respectively. Somewhat unexpectedly, for both scenarios and almost all groups, more people indicated no shift than positive or negative shifts in expected impacts. The average score shifts are only significant for the expected impacts on very few groups – other neighborhoods and cyclists in the dedicated scenario (Figure 13). Both significant shifts are positive, meaning participants have more positive expectation of impacts of the dedicated lane scenario on other neighborhoods and cyclists. This may relate to the negative initial expectations of impacts on these two groups, which suggests that participants did not think the additional BRT routes would have positive impacts on other neighborhoods or cyclists before using CoAXs. Participants' expected impacts of the dedicated lane scenario on themselves, their neighborhood, the city, pedestrians, private vehicle users, and public transport users all slightly shifted positive, although this shift is not statistically significant. This suggests that for some participants, perceived impacts of the dedicated lane scenario after the workshops exceeded their initial expectations.

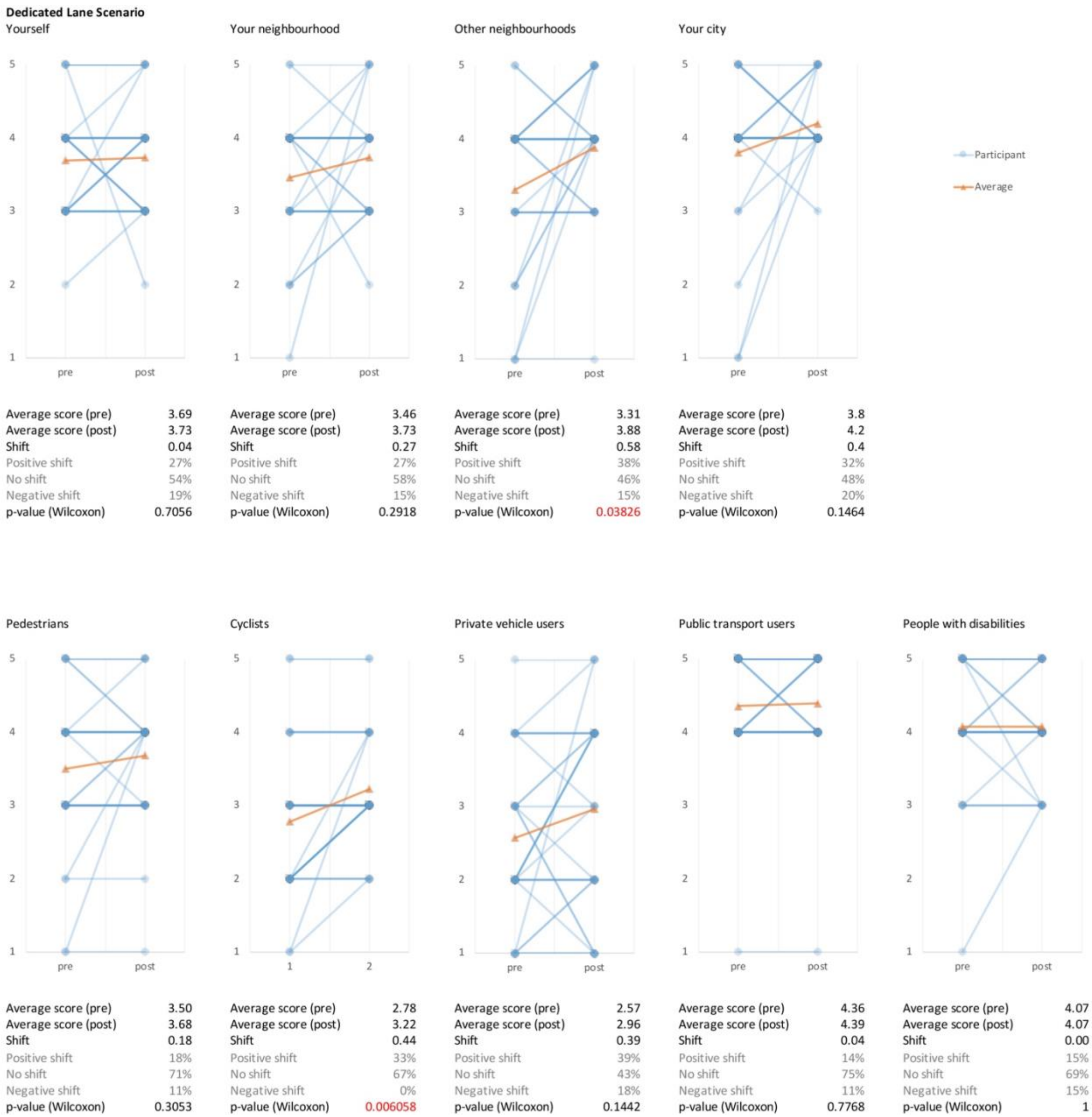


Figure 13: Overall shifts of expected impacts (dedicated lane scenario)

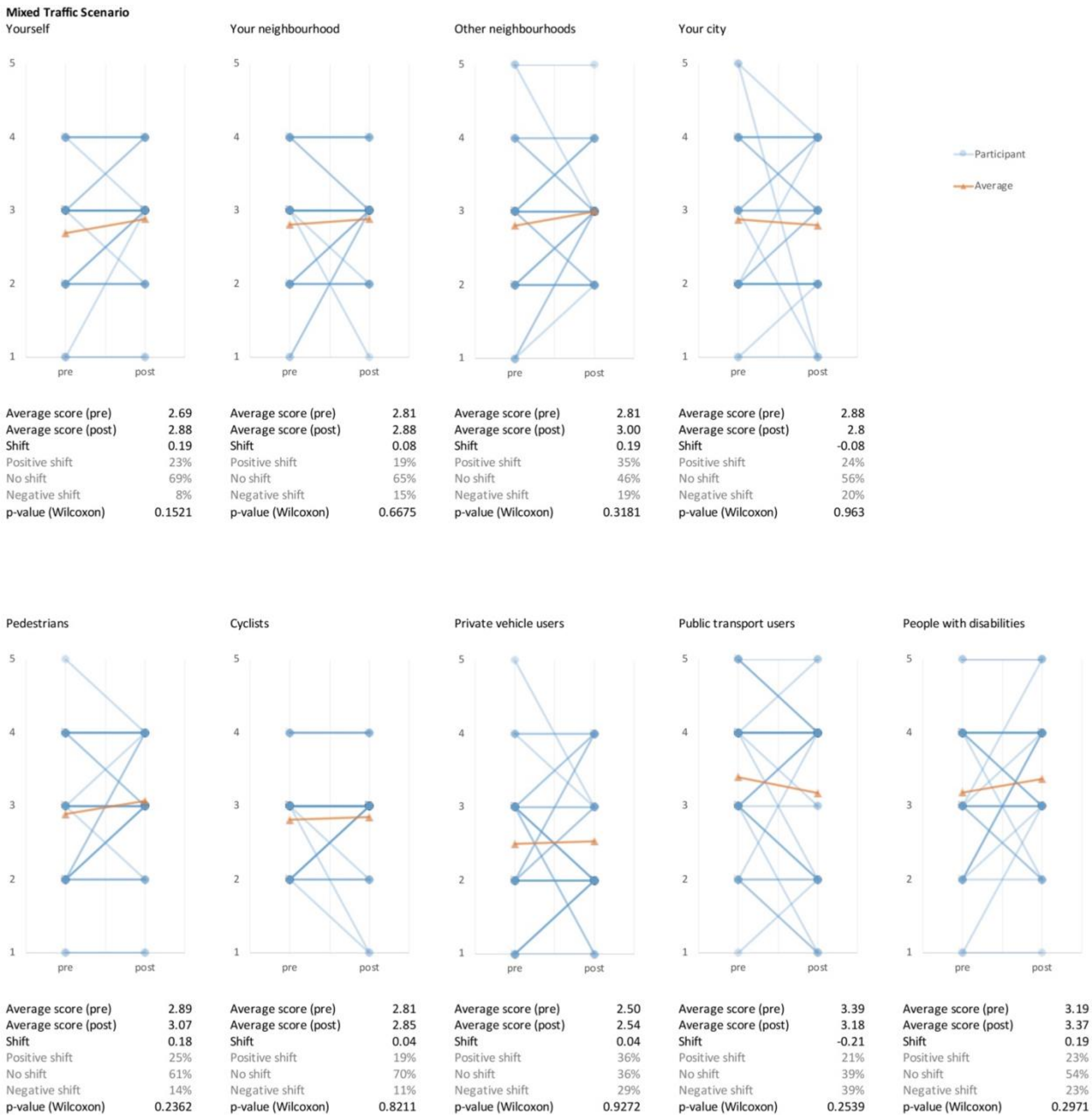


Figure 14: Overall shifts of expected impacts (mixed traffic scenario)

As shown in Figure 14, expected impacts of the mixed traffic scenario on all groups have slight, insignificant shifts. Different from the dedicated lane scenario, expected impacts on the city and public transport users have negative shifts, meaning that the initial expected positive impacts of the mixed traffic scenario on these two groups did not take place, as measured after the workshops. Specifically, the downward shift in the expected impacts on public transport users was more noticeable (0.21) with 39% of participants shifting negative; this may suggest participants' disappointment when seeing relatively limited increase in accessible regions when the mixed traffic scenario was selected, especially for origin points farther away from the proposed route and with a relatively tight time constraint. Seeing the relatively larger improvements in the dedicated scenario may have also contributed to the disappointment.

In general, the lack of significant changes in expected impacts on different scopes and groups is surprising, but can be partly explained by some comments made in the workshops. First, participants in all four workshops expressed concerns that the proposed Line 2B does not address the needs of commuters with the greatest needs in the city – the working class who live in the more remote townships. Some participants moved the origin point pin to those townships and saw no improvements to their accessibility, as they expected before the workshops. Second, some participants argued that given the current operating frequency and speed of *A Re Yeng*, commuting on the BRT still takes much longer than driving. In the workshops, many participants placed the origin point at their home or work locations and adjusted the time slider to see the travel time to their destination, and many of them said the travel time is longer than driving, as they expected initially. Finally, some participants suggested that improving and fully integrating the existing public transport network should be prioritized rather than introducing a new BRT network. These initial expectations were then confirmed when participants observed limited isochrones with only the BRT network, even in the most extensive scenario with the dedicated trunk lane scenario and all the feeder routes on.

5.3.2.2 Expected Project Impacts across User Groups

Statistical tests are also conducted to examine shifts in expected impacts in both scenarios for each user group separately. Table 9 presents the test results, with significant results ($\alpha = 0.1$) highlighted in italics with shift numbers in brackets. In the dedicated lane scenario, car users have significantly positive shifts in expected impacts on the city, cyclists, and private vehicle users, while non-car users' expected impacts do not have significant shifts. This suggests that the car users' negative expectations of the proposed BRT route are alleviated after using CoAXs in the dedicated lane scenario. The improved expectations of impacts on the city and cyclists may be an indicator of a broader understanding of potential impacts brought by BRT, and a growing empathy towards commuters using other modes. The improved expectations of impacts on private vehicle users reported by car users, combined with their insignificant shift in expected impacts on themselves, suggest that CoAXs helped car users see their benefits from the BRT at a collective group level, but not necessarily at the individual level.

Table 9: Wilcoxon signed-rank test results (p-values) for shifts in expected impacts from each user group

	Car users		**Non-car users**	
	Dedicated lane	Mixed traffic	Dedicated lane	Mixed traffic
Yourself	0.7768	0.7728	1	0.2031
Your neighborhood	0.8902	0.8501	0.1058	0.4076
Other neighborhoods	0.1696	0.4821	0.1596	0.5877
Your city	*0.05676* **(+0.67)**	0.5716	0.8211	0.6653
Pedestrians	0.3447	1	0.8501	0.1198
Cyclists	*0.02627* **(+0.50)**	0.1489	0.1736	0.5716
Private vehicle users	*0.03565* **(+0.67)**	0.4374	1	0.5182
Public transport users	0.7656	0.1975	1	1
People with disabilities	0.8501	0.6153	0.8501	0.4076

Note: Numbers in italics represent statistically significant ($\alpha = 0.1$) shifts from pre- to post- workshop based on Wilcoxon signed-rank tests, and bold numbers in brackets represent the magnitude of the significant shifts.

As introduced earlier in this section, Mann-Whitney U tests are also used to test differences between scores from the two user groups both pre- and post-workshop. Table 10 shows the impact categories on which the expected impacts are significantly different between the two user groups either before or after the workshop, with significant *p*-values indicating differences between the groups highlighted in italics, and significant shifts highlighted in bold (and detailed in Table 9). The results in Table 10 are specific to the dedicated lane scenario only; there was no significant difference in responses from the two user groups in expected impacts on any of the impact categories in the mixed traffic scenario.

Table 10: Pre- and post-workshop comparison of expected impacts between user groups (dedicated lane scenario)

		Yourself	**Your city**	**Private vehicle users**	**Public transport users**	**Your neighborhood**
Pre-workshop	Average score (Car users)	3.33	3.46	2.13	4.13	3.47
	Average score (non-car users)	4.13	4.20	2.93	4.67	3.67
	p-value (Mann-Whitney)	*0.0043*	*0.0016*	*0.0563*	*0.0626*	*0.3298*
Post-workshop	Average score (Car users)	3.43 (+0.10)	**4.13 (+0.67)**	**2.80 (+0.67)**	4.20 (+0.07)	3.43 (-0.04)
	Average score (non-car users)	4.08 (-0.05)	4.17 (-0.03)	3.15 (+0.22)	4.62 (-0.05)	4.0 (+0.42)
	p-value (Mann-Whitney)	*0.0283*	0.8789	0.4741	0.229	*0.0325*

Note: Numbers in italics represent statistically significant ($\alpha = 0.1$) differences between the two user groups (car users versus non-car users) from Man-Whitney U tests. Numbers in brackets represent shifts of average scores from pre- to post-workshop responses, and bold numbers in brackets represent statistically significant ($\alpha = 0.1$) shifts from Wilcoxon signed-rank tests.

As shown in Table 10, the two groups' expected impacts of the dedicated lane scenario on themselves, the city, private vehicle users, and public transport users tended to converge after the workshops (i.e., shifting from a more significant *p*-value to a less significant or insignificant one). The car users started with much lower expectation of the impacts on themselves than the non-car users, while after using CoAXs, the car users had a slightly more positive expectation while the non-car users had a slightly more negative expectation, resulting in a closer, but still different post-workshop expected impacts on themselves. The positive shift among the car users in their expected impacts on themselves is consistent with their significant positive shift in expected impacts on private vehicle users (+0.67). As for impacts on the city and public transport users, positive shifts in car users' expectations, combined with negative shifts in non-car users' expectations, resulted in similar expectations between the two groups after the workshops. Aside from the indication of growing empathy among car users, i.e., seeing benefits of the proposed project for other commuters, this change may also indicate disappointment among non-car users seeing limited benefits to themselves. In addition, although the non-car users' expected impacts on themselves shifted negatively, their expectations of impacts on private vehicle users had a slightly positive shift (+0.22). This suggests that CoAXs helped non-car users see less adverse anticipated effects on the car users of the proposed project.

For expected impacts on their neighborhoods, responses from the car users and non-car users tend to diverge (i.e., shifting from an insignificant *p*-value to a significant one). With higher initial expectations among the non-car users and a positive shift, they had a much higher expectation of impacts on their neighborhoods than the car users. This is expected since most car users came from the more affluent neighborhoods closer to the Menlyn end of the corridor, while most non-car users came from the student neighborhood of Hatfield (refer to Figure 8). In discussions among the car users, they raised concerns about increased density in their neighborhoods along the proposed Line 2B. Moreover, since the existing Line 2A ends in Hatfield, stations in Hatfield would have much higher centrality in the BRT network after the introduction of Line 2B. As a result, the accessibility improvements shown in CoAXs are much larger when the origin point is located closer to the existing network, while the accessibility isochrones from an origin point closer to the Menlyn end only expand along Line 2B (as shown in Figure 15). Therefore, it is unsurprising that the expected impacts on their neighborhoods would improve among non-car users after the workshops.

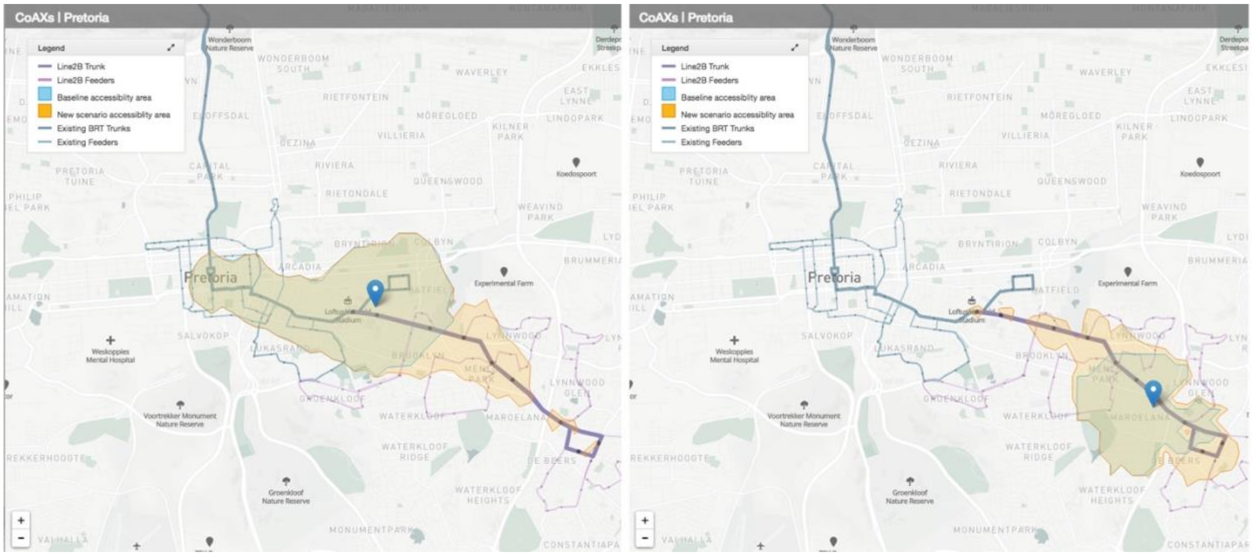


Figure 15: 30-minute isochrones from different origin points with only dedicated lane trunk selected (left: Hatfield, right: Menlyn)

5.3.3 Attitudes and Enthusiasm

Participants' attitudes and enthusiasm towards the proposed projects is measured by asking them to respond to seven different statements using a Likert score scale, with 1 representing "strongly disagree" and 5 representing "strongly agree" (refer to surveys in Appendices). The first two statements measure participants' attitudes to the proposed projects by asking if they agree that the projects help achieve transportation goals and broader urban goals. The following three statements measure participants' enthusiasm for the projects by asking if they would be willing to use the proposed BRT route, or to let their children use it, or to advocate for it. The final two statements measure participants' attitudes to accessibility as a key term in decision making and public participation processes regarding transportation planning. Similar to the analysis of expected impacts, average scores and overall shifts are first analyzed, and then scores from the two user groups were separately tested and compared.

5.3.3.1 Attitudes and Enthusiasm among All Participants

Figure 16 summarizes the pre- and post-workshop scores and their shifts among all participants. Unexpectedly, responses to the statement “I would be willing to let my children use the proposed Line 2B BRT to commute” have a significant negative shift (-0.32, $p = .04$ in the Wilcoxon test). This may be a result of a high initial expectation that the stops would be nearby and the service would operate with high frequencies. A few times during the workshops, participants placed the origin point so far from any BRT station that most of the area in the resulting isochrone was reached by walking. Showing such a long walking distance might raise participants’ concerns about safety, and therefore reduce their willingness to let their children use the BRT. Other noticeable, although not statistically significant shifts include a negative shift in participants’ agreement with the statement that the proposed Line 2B will effectively improve transportation in the city; this is consistent with comments made in all workshops that Line 2B is not at the most needed location. However, responses to the statement that the proposed Line 2B will help advance important broader urban goals indicate a slight positive shift, which suggests that participants were able to understand the broader impacts of the project through the workshops. This is in alignment with participants’ increased expectations for impacts on the city, as discussed in the preceding subsection. Furthermore, participants’ agreement with the statement that “I would be willing to use the proposed Line 2B BRT to commute” indicated a small negative shift, which also aligns with the previously discussed disappointment with limited observed improvements to accessibility. For all the questions in this section of the survey, the majority of participants did not shift in their responses. This suggests that using CoAXs in these workshops had a generally limited impact on changing participants’ attitudes and enthusiasm.

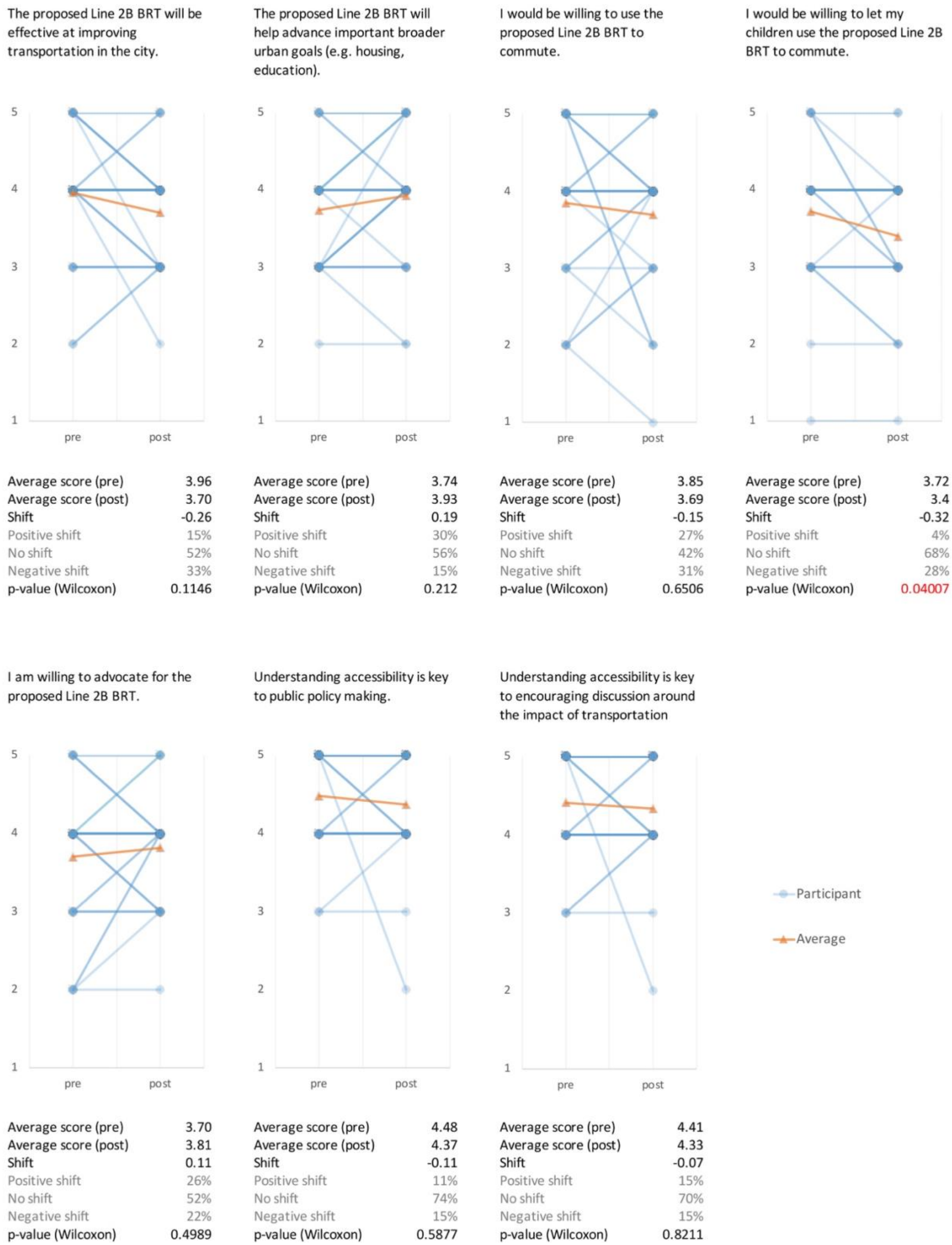


Figure 16: Overall shifts of attitudes and enthusiasm

5.3.3.2 Attitudes and Enthusiasm across User Groups

Similar to the analysis of participants' expectations regarding impacts, I also use statistical tests to examine shifts in the mean scores for the two user groups separately. The results show that neither of the groups have a significant ($\alpha = 0.1$) shift in responses to any of the questions. This suggests that the workshops were not effective in changing either user group's attitudes towards the proposed projects or enthusiasm in using or advocating for the projects.

However, a Mann-Whitney U test for differences between the two user groups before and after workshop suggests diverging responses to the statement "I would be willing to use the proposed Line 2B BRT to commute" (but car users' willingness dropped more than that for non-car users. Aside from their high dependence on their cars, this could also relate to the previously discussed point that the Line 2B trunk route brings smaller accessibility improvement to the neighborhoods where the car users live than to the neighborhoods where the non-car users live.

Table 11). Before the workshops, non-car users were slightly more willing to use the proposed BRT route, and after the workshops, they were significantly more willing to use it than the car users. Both participant groups reported a reduced willingness to use the BRT, but car users' willingness dropped more than that for non-car users. Aside from their high dependence on their cars, this could also relate to the previously discussed point that the Line 2B trunk route brings smaller accessibility improvement to the neighborhoods where the car users live than to the neighborhoods where the non-car users live.

Table 11: Pre- and post-workshop comparison of attitude and enthusiasm between user groups

		I would be willing to use the proposed Line 2B BRT to commute
Pre-workshop	Average score (Car users)	3.54
	Average score (non-car users)	4.19
	p-value (Mann-Whitney)	0.1098
Post-workshop	Average score (Car users)	3.21 (-0.32) *p*-value (Wilcoxon) = 0.4541
	Average score (non-car users)	4.15 (-0.03) *p*-value (Wilcoxon) = 0.8241
	p-value (Mann-Whitney)	*0.0119*

Note: Numbers in italics represent statistically significant *p*-values from the tests specified in the table. Numbers in brackets represent shifts of average scores from pre- to post-workshop responses.

5.3.4 Tool Usability and Usefulness

Two sets of questions in the post-workshop survey measured the usability and usefulness of CoAXs. Again, participants were asked to whether they agree with each statement or not, using a 5-point Likert scale, with 1 representing “strongly disagree” and 5 representing “strongly agree” (see surveys in Appendices).

Figure 17 shows the responses from all participants to the four questions measuring the usability of CoAXs. The tool received positive ratings in general, with over 50% of participants indicating “agree” or “strongly agree” with all four statements. Nonetheless, about 25% of participants disagreed with the statement: “I would imagine that most people would learn to use CoAXs very quickly.” This aligns with feedback received in the third and fourth workshops, where all the participants were young adults and they voiced concern that it may take longer for other people, who are not familiar with digital devices, to learn to use CoAXs. Based on workshop experiences in Pretoria, proper introduction to the terms used in the tool and demonstration of usage are generally helpful in getting participants started and familiarized. The presence of staff to assist when users face problems is also necessary.

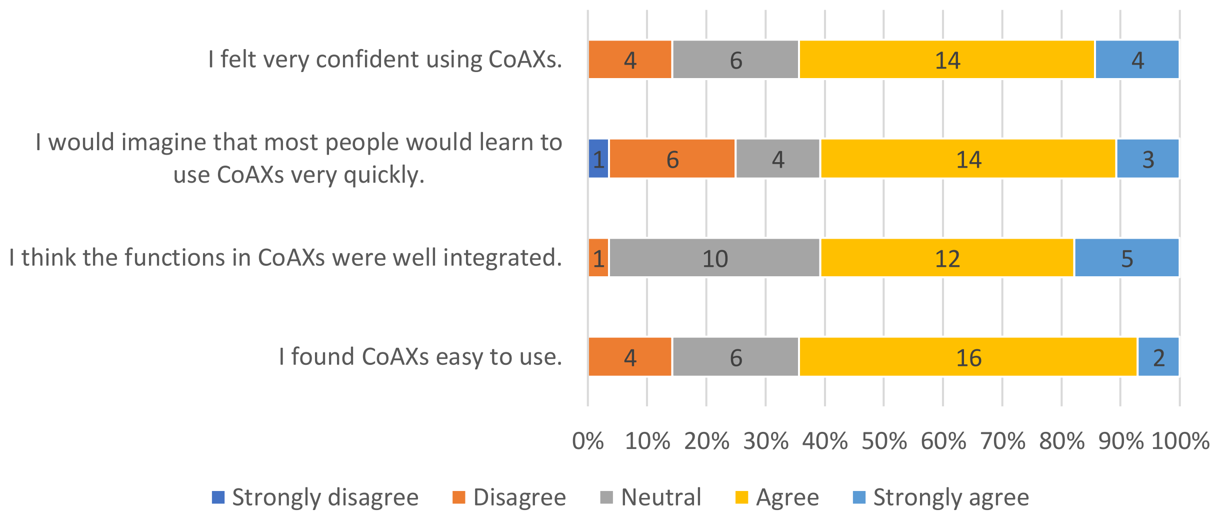


Figure 17: Reponses to post-workshop CoAXs usability questions

The usefulness of CoAXs was measured with seven statements, targeting different aspects of its uses; the responses are presented in Figure 18. First, participant expressed broad agreement that CoAXs could be useful in a public meeting setting to support teamwork and meaningful conversation. All respondents agreed with the statement that “I would imagine CoAXs to be a useful tool in future public meetings about proposed public transport improvements,” over 80% of participants agreed (and none disagreed) that “CoAXs helped raise important issues for discussion” and “CoAXs provided a useful common ground for all participants to work together," and over 80% of participants disagreed that "CoAXs distracted people from conversation."

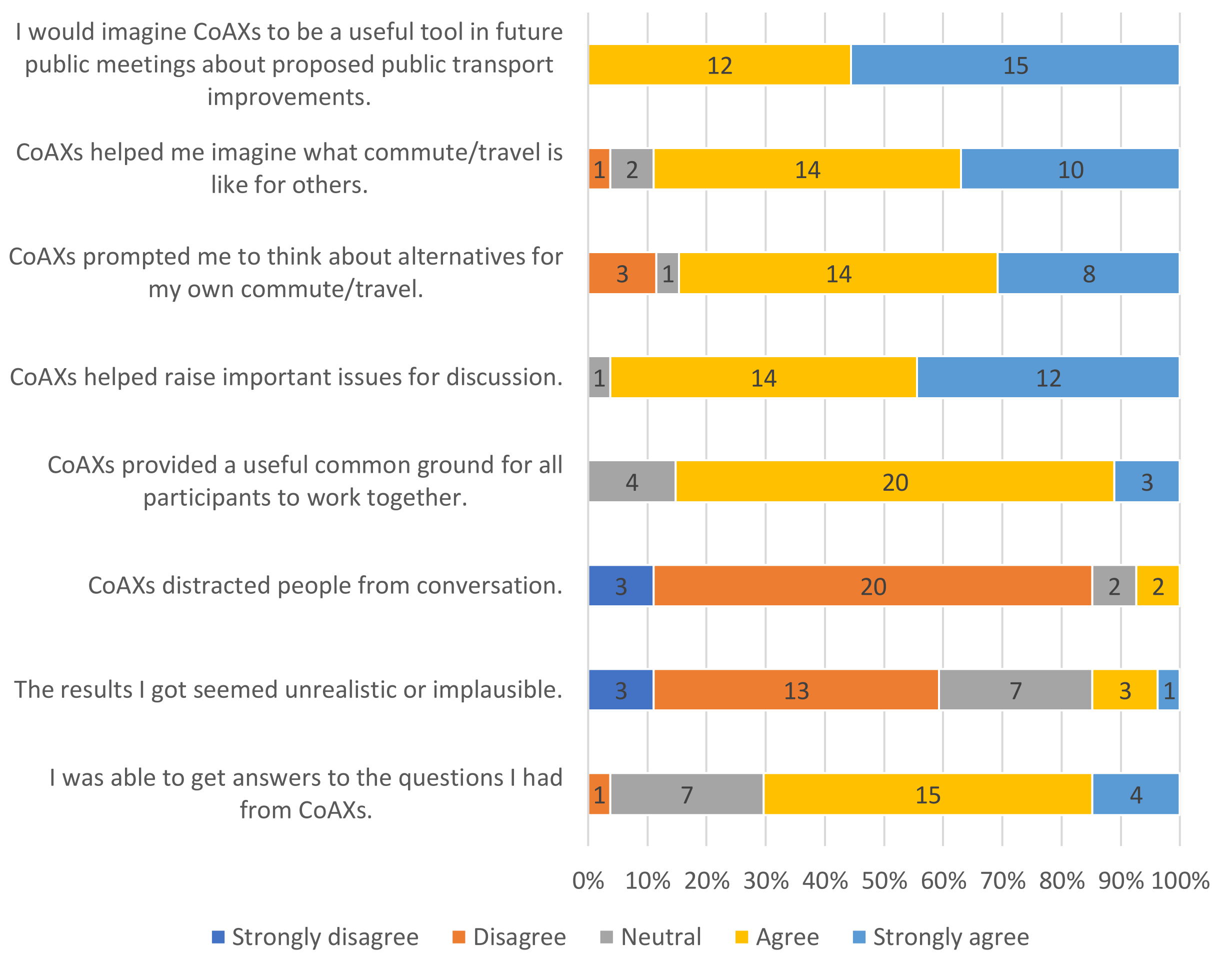


Figure 18: Reponses to post-workshop CoAXs usefulness questions

In terms of building empathy, CoAXs also prompted participants to imagine travel alternatives for themselves and the trips of others. A strong majority of participants agreed with the statements: "CoAXs helped me imagine what commute/travel is like for others" and "CoAXs prompted me to think about alternatives for my own commute/travel." A small number of participants disagreed with these two statements, which may be related to pre-workshop empathy towards public transport commuters among some participants in the first two workshops. For example, because of their familiarity and previous involvements with the proposed projects, participants in Workshop 1 had already (before the workshop) gained some understanding of the needs of lower-income commuters and the importance of empathy in resolving the conflicts; in fact, some even brought up the issue of empathy at the very beginning of the workshop.

As for information representation, over half of the participants indicated that CoAXs' results were realistic and that they were able to get answers to the questions they had. However, four people agreed that "The results I got seemed unrealistic or implausible." Questions about the reliability and accuracy of the results were raised in multiple workshops, mostly regarding travel times in the mixed-traffic scenario, which seemed much longer than their experiences driving. It is important to clarify that all travel time calculations were made with rush hour assumptions (i.e., slower average speed). Participants also raised questions about CoAXs' not representing the BRT proposal's integration with the existing public transport network in the Pretoria CoAXs instance. This limitation produces smaller isochrones than which would likely result given the possibility to transfer between different networks in reality.

5.4 Comparison with the 2016 Boston Experiment

This section compares the experiment results discussed above with the results from the 2016 workshops conducted in Boston regarding bus priority projects (introduced in Section 3.1). Specifically, the results from this study are primarily compared with the results from the accessibility version in the Boston experiment, the most directly comparable version to the Pretoria instance.

First, participants in the two experiments presented similar patterns of shifts in their expected impacts. In both experiments, expected impacts on public transport users did not shift positively. In the Boston experiment, users of the accessibility version reported a significant downward shift in expected impacts on public transport riders, with 53% of participants shifting negatively (Stewart, 2017). In the Pretoria experiment, participants' responses indicated a negligible shift for the dedicated lane scenario, and an insignificant, but noticeable downward shift for the mixed traffic scenario, with 39% of participants shifting negative. Meanwhile, expected impacts on the neighborhood, pedestrians, and private vehicle drivers had positive shifts in both experiments. These similarities suggest that in both experiments, CoAXs was helpful in broadening the scope of participants' expected impacts.

Second, effects of CoAXs on participants' enthusiasm for proposed public transport projects differed in the two experiments. The Boston experiment found that, compared to the point-to-point version, where car users were more likely to shift negatively in their enthusiasm for the bus priority projects, the accessibility version alleviated the predisposition of car users to be less enthusiastic (Stewart, 2017). However, in the Pretoria experiment, the participants generally had a significant downward shift in their enthusiasm for the proposed BRT projects; among the participants, car users had a large negative shift in their willingness to use the BRT, and had significantly lower willingness to use the BRT than the non-car users, post-workshop. Admittedly, the Pretoria workshops did not have a point-to-point version for comparison with the accessibility version and the willingness to use BRT does not necessarily represent enthusiasm. At minimum, the different results from the two experiments point to the complexity of measuring enthusiasm shifts and suggest that the effects of CoAXs on participants' enthusiasm cannot be easily generalized.

Finally, participants in the two experiments had similar responses to the usefulness of CoAXs in public meetings for transport planning, but had different responses to its usefulness in empathy building. In both experiments, participants generally agreed that CoAXs would be helpful in providing a common ground for useful conversations, helped raise important issues for discussion, and would help support conversations in future planning meetings. The statement that "CoAXs helped me imagine what travel is like for others" also received agreement from strong majorities of participants in both experiments. However, in the Boston experiment, a substantial percentage of participants disagreed that the tool prompted them to think about their own travel, while this statement received over 80% agreement in Pretoria. This disparity might be a result of different participant recruitment strategies; the Pretoria experiment targeted residents in surrounding neighborhoods of the proposed BRT route, while participants in the Boston experiments were members of an advocacy organization and did not necessarily live in proximity to the discussed projects. A closer examination of the participant recruitment process and participant demographics may shed additional light on the differences in responses.

Chapter 6: Conclusions

6.1 Conclusions

Based on the results and analysis in the preceding chapter, this chapter summarizes the major findings regarding the research questions.

First, the results suggest that CoAXs was effective in improving users' knowledge of the proposed BRT routes and moderately effective in broadening the scope of users' understanding of possible impacts of the proposed BRT routes across the entire city, but not effective in improving users' attitudes towards the proposed BRT routes. Moreover, CoAXs may have negatively shifted workshop participants' attitudes to and enthusiasm for the proposed projects, by causing disappointment when showing accessibility improvements that did not meet the participants' initial expectations. Comparing participants who were car users versus non-car users, CoAXs was more effective in broadening car users' understanding of project impacts, supported by evidence that car users had significantly more positive expected impacts of the projects on the city and cyclists. In addition, after the workshops non-car users were significantly more willing to use the proposed BRT routes than car users, due to large negative shift in the latter's stated willingness to use the routes.

Second, CoAXs was effective in helping users, especially car users, to better understand the expected impacts of the proposed BRT routes on other user groups and, hence, helped foster empathy between car users and non-car users. This is supported by significant positive shifts in car users' expected impacts of the proposed BRT routes on users of other modes, and positive shifts in non-car users expected impacts on car users, resulting in converged expectations between the two user groups. This is also supported by participants' agreement with the statement: "CoAXs helped me imagine what commute is like for others".

Third, the option of interacting with CoAXs on a laptop was preferred by some participants, mainly because of being uncomfortable in front of a large group. The laptop users formed smaller groups to interact with CoAXs together and discuss, instead of using it individually.

Finally, participants gave CoAXs high ratings regarding its usability and generally high ratings on its usefulness as a public engagement tool. This indicates that the adapted CoAXs instance for Pretoria was suitable for the context in fulfilling its intentions.

6.2 Limitations and Future Research

This study faced several practical constraints, but also provides lessons and areas of interest for future research.

First, as discussed in Chapter 3, lack of necessary data prevented the development of some desired capabilities, such as private vehicle accessibility and cost-constrained isochrones. In addition, the accuracy of the visualized accessibility in the Pretoria CoAXs instance was limited because of the unavailability of GTFS for other public transport services and the informal minibus taxi service. Future research in other contexts will benefit from efforts to obtain required data early on in the development process and to make use of other tools to create GTFS for existing public transport services.

Second, the small sample size in this study limited the inferential statistical analysis. The participation rate was much lower than expected, especially at the first two workshops, where only 11 people attended out of over 7,000 people who received an announcement of the event directly from their ward councilor. A follow-up interview with the ward councilor suggested that attendance at public meetings varies according to the topic and that an earlier meeting in the same ward on the same proposed BRT route attracted around 600 participants. This supports feedback received from participants that these workshops would be more effective if they were held earlier in the project timeline. Therefore, in future research with similar intentions, it would be particularly relevant to deploy CoAXs much earlier in the project identification stage, identify the public's interest level in the project, and improve effectiveness of outreach to attract more participants. With more participants, and hence a larger sample size, we would be able to draw insights from data with more confidence.

Finally, the laptop version tested in this study was very preliminary. Future research is needed to find out whether laptop users have better understanding of the features and impacts of the proposed projects. It is also potentially interesting to look into whether a workshop with only laptops can achieve similar effects as a workshop with a touch screen, which would help justify a different workshop approach in more logistically constrained contexts.

In general, this experiment shows the potential effectiveness of CoAXs, as an accessibility-based visualization tool, in facilitating public engagement in a context of severe social segregation. Enthusiasm for the tool among workshop participants and city officials suggests such a tool holds some promise in contributing to future decision-making processes. Reflecting on the entire experiment process, it is also important to note that, despite the attractiveness of technically advanced and aesthetically appealing visualizations, public participation in public transport planning is essentially a political process, requiring substantial commitment and likely shifts in to institutions and mindsets to achieve meaningful improvements.

References

Bothma, S. (2015, April 24). Lynnwood BRT lane fury grows. *Rekord East*. Retrieved from https://rekordeast.co.za/49283/lynnwood-brt-lane-fury-grows/

Bryceson, D. F., Bradbury, A., & Bradbury, T. (2008). Roads to Poverty Reduction? Exploring Rural Roads' Impact on Mobility in Africa and Asia. *Development Policy Review*, *26*(4), 459–482. https://doi.org/10.1111/j.1467-7679.2008.00418.x

Bryceson, D. F., & Howe, J. (1993). Rural household transport in Africa: Reducing the burden on women? *World Development*, *21*(11), 1715–1728. https://doi.org/10.1016/0305-750X(93)90079-O

Bubeck, S., Tomaschek, J., & Fahl, U. (2014). Potential for mitigating greenhouse gases through expanding public transport services: A case study for Gauteng Province, South Africa. *Transportation Research Part D: Transport and Environment*, *32*(Supplement C), 57–69. https://doi.org/10.1016/j.trd.2014.07.002

Cheng, P. T. (2016). *Toward a multi-scale participatory urban policymaking platform: co-designing Mass Transit using LEGO bricks, open data, and interactive pixels* (Thesis). Massachusetts Institute of Technology. Retrieved from http://dspace.mit.edu/handle/1721.1/105070

Friedman, S., Hlela, K., & Thulare, P. (2005). A Question of Voice: Informality and Pro-Poor Policy in Johannesburg, South Africa. In N. Hamdi & J. Handal (Eds.), *Urban Futures: Economic growth and poverty reduction*. Rugby, Warwickshire, United Kingdom: Practical Action Publishing. https://doi.org/10.3362/9781780446325

Ismail Vadi. (2017, July). *A Re Yeng -Tshwane Rapid Transit Progress Report*. Presented at the 36th Southern African Transport Conference, Pretoria, South Africa.

Lucas, K. (2011). Making the connections between transport disadvantage and the social exclusion of low income populations in the Tshwane Region of South Africa. *Journal of Transport Geography*, *19*(6), 1320–1334. https://doi.org/10.1016/j.jtrangeo.2011.02.007

Madumo, O. S. (2011). *The role of ward committees in facilitating public participation with particular reference to Mamelodi, South Africa*. University of Pretoria.

Mahapa, S. M., & Mashiri, M. (2001). Social exclusion and rural transport: gender aspects of a road improvement project in Tshitwe, Northern Province. *Development Southern Africa*, *18*(3), 365–376. https://doi.org/10.1080/03768350120070026

Masango, R. S. (2008). Enhancing the Efficacy of Public Participation in Policy-Making and Implementation through Civic Education: A South African Perspective. *International Journal of Learning*, *15*(6), 65–71.

Mbuyisa, S. (2013). Public participation as participatory conflict resolution: Shortcomings and best practices at the local level in South Africa. *African Journal on Conflict Resolution*, *13*(3), 115–140.

Metrorail trains are running at least an hour late this morning. (2017, September 22). *Kempton Express*. Retrieved from https://kemptonexpress.co.za/157366/metrorail-trains-running-least-hour-late-morning/

Metrorail trains suspended between two Pretoria stations after violence. (2018, March 14). *TimesLive*. Retrieved from https://www.timeslive.co.za/news/south-africa/2018-03-14-metrorail-trains-suspended-between-two-pretoria-stations-after-violence/

Metrorail trains torched in Pretoria. (2016, February 24). *ENCA*. Retrieved from /south-africa/metrorail-trains-torched-pretoria

Moatshe, R. (2017, September 19). Tshwane's BRT east line snag | Pretoria News. *IOL*. Retrieved from https://www.iol.co.za/pretoria-news/tshwanes-brt-east-line-snag-11272958

Mokonyama, M., & Venter, C. (2013). Incorporation of customer satisfaction in public transport contracts – A preliminary analysis. *Research in Transportation Economics*, *39*(1), 58–66. https://doi.org/10.1016/j.retrec.2012.05.024

Municipal Demarcation Board. (2016). Ward Delimitation. Retrieved August 19, 2018, from http://www.demarcation.org.za/site/ward-delimitation/

Navas Duk, C. (2017). *Testing collaborative accessibility-based engagement tools : Santiago de Chile case* (Thesis). Massachusetts Institute of Technology. Retrieved from http://dspace.mit.edu/handle/1721.1/113736

Stakeholder Engagement. (2015). Retrieved September 6, 2018, from http://www.tshwane.gov.za/sites/areyeng/stakeholders/pages/stakeholders.aspx

Stewart, A. F. (2014). *Visualizing urban accessibility metrics for incremental bus rapid transit projects* (Thesis). Massachusetts Institute of Technology. Retrieved from http://dspace.mit.edu/handle/1721.1/92057

Stewart, A. F. (2017). *Advancing accessibility: public transport and urban space* (Thesis). Massachusetts Institute of Technology. Retrieved from http://dspace.mit.edu/handle/1721.1/111444

Stewart, A. F., & Zegras, P. C. (2016). CoAXs: A Collaborative Accessibility-based Stakeholder Engagement System for communicating transport impacts. *Research in Transportation Economics*, *59*, 423–433. https://doi.org/10.1016/j.retrec.2016.07.016

Stewart, A. F., Zegras, P. C., Tinn, P., & Rosenblum, J. (2018). Tangible Tools for Public Transportation Planning: Public Involvement and Learning for BRT Corridor Design. Retrieved from https://trid.trb.org/view/1496562

The minibus taxi industry in South Africa: A servant for the urban poor? (2013, May 6). Retrieved September 6, 2018, from http://www.polity.org.za/article/the-minibus-taxi-industry-in-south-africa-a-servant-for-the-urban-poor-2013-05-06

Tshwane A Re Yeng bus plan ’faulty’ : Property News from IOLProperty. (2015, October 16). *Pretoria News*. Retrieved from http://www.iolproperty.co.za/roller/news/entry/tshwane_a_re_yeng_bus

Venter, C. (2011). Transport expenditure and affordability: The cost of being mobile. *Development Southern Africa*, *28*(1), 121–140. https://doi.org/10.1080/0376835X.2011.545174

Venter, C. (2013). The lurch towards formalisation: Lessons from the implementation of BRT in Johannesburg, South Africa. *Research in Transportation Economics*, *39*(1), 114–120. https://doi.org/10.1016/j.retrec.2012.06.003

Venter, C. (2016). Assessing the potential of bus rapid transit-led network restructuring for enhancing affordable access to employment – The case of Johannesburg’s Corridors of Freedom. *Research in Transportation Economics*, *59*(Supplement C), 441–449. https://doi.org/10.1016/j.retrec.2016.05.006

Venter, C., Vokolkova, V., & Michalek, J. (2007). Gender, Residential Location, and Household Travel: Empirical Findings from Low-income Urban Settlements in Durban, South Africa. *Transport Reviews*, *27*(6), 653–677. https://doi.org/10.1080/01441640701450627

Zheng, X. (2018). *Design and deploy: co-creative public transport planning using a web -based stakeholder engagement tool* (Thesis). Massachusetts Institute of Technology. Retrieved from http://dspace.mit.edu/handle/1721.1/115802

Appendices

Appendix A: Information Sheet for Workshop Participants

Definitions and Scenarios

Definitions

CoAXs (Collaborative Accessibility-based stakeholder engagement): The interactive accessibility tool you will be making use of today. It was developed by the Massachusetts Institute of Technology (MIT). The tool assists in visualising the accessibility impacts of various transport projects.

Accessibility: The ease or difficulty of reaching a desired destination or opportunity (jobs, healthcare facilities, educational institutions etc.) from a particular location, taking into account both transport and land-use. We are measuring accessibility as the number of jobs one can reach within a specified time constraint from a specified location.

Isochrone: The geographical area accessible using the available modes of transport from a specified location.

A **commute** is a journey taken on a regular basis between one's home and place of work or school. A **commuter** is a person who makes such a journey.

BRT: Bus Rapid Transit (BRT) is a high-quality bus system that aims to deliver a comfortable, fast and cost effective service through measures such as, dedicated right-of-way in exclusive bus lanes, enclosed stations with pre-fare collection and higher capacity buses. Examples of such systems in South Africa are: A Re Yeng in Pretoria, Rea Vaya in Johannesburg and MyCiti in Cape Town. The classic trunk-feeder BRT model is adopted in South Africa. This model enables the use of smaller vehicles in lower-density areas, while the main corridors carry higher capacities of passengers in larger vehicles.

Trunks: This service operates on major routes that connect two prominent parts of a city. Trunk routes have generally long distances and usually operate on dedicated bus lanes.

Feeders: This service delivers commuters from surrounding areas to nearby transportation hubs and vice versa. Due to their reduced passenger capacities, lower frequencies and slighter/narrower roads, feeders usually operate in mixed traffic.

Dedicated bus lane: A lane within a road that is meant only for public transport e.g. BRT buses. They allow for faster travel by avoiding traffic congestion. However, emergency services and police may be allowed to use them on occasion. These lanes are often positioned in the middle of the road (median), or next to the side pavement (curbside).

Mixed traffic lane: A lane that is used by both public transport and passenger vehicles. There are no formal facilities or measures within the road that directly benefit public transport, meaning that all modes in these lanes are sensitive to congestion and do not receive any travel time benefits.

Frequency is the number of buses that pass a particular point or station, in a particular direction, within a given period of time. **Headway** is the measurement of time or distance between vehicles. For example, a frequency of 2 buses per hour indicates that a bus passes a particular station, in a particular direction, every 30 minutes. The headway would then be 30 minutes per vehicle. Frequencies and headways can be increased or decreased during the day, or on specific routes to suit passenger volumes.

Timetable: This is a schedule that provides information about the services of a public transport mode, thus allowing a user to plan their trip. Timetables may include operational hours, departure and arrival times, as well as bus frequencies.

Data and data sources

Measuring accessibility requires both land-use and transport data. The data sources are as below:

Opportunity data: The distribution of jobs, across various sectors, in Pretoria in 2014. (Source: CSIR)

Transport data: The existing A Re Yeng BRT network as found on movinggauteng.co.za. The frequency and timetable data was used to estimate the speed of the service on the various lines.

Scenarios and assumptions

You can compare a new scenarios from the hypothetical scenarios we have built into CoAXs to a baseline scenario which remains unchanged.

Baseline scenario:

- Existing A Re Yeng BRT network: To visualise the accessibility provided by the existing A Re Yeng network. This is also referred to as the **baseline scenario**. Table 1 outlines the properties of the routes that make up the baseline scenario.

Table 1: Route properties in the baseline scenario.

Route	Description	Speed (km/h)	Headways (minutes)
Line1A	Trunk between CBD and Pretoria North	25	5
Line2A	Trunk between Molefe Makinta Station and General M. Siyothula Station	25	7
F1	Feeder between Ruth Mompati Station and Steve Biko Hospital	15	10
F4	Feeder between Mahatma Gandhi Station and TUKS Groenkloof	15	30
F5	Feeder between Nana Sita Station and Belle Ombre	15	15
F6	Another feeder route between Nana Sita Stn and Belle Ombre	15	20
F7	Another feeder between Mahatma Gandhi Station and TUKS Groenkloof	15	60

*All speeds and headways are of the morning peak period on typical weekdays

New scenarios:

Line 2B can be analysed as operating in **one** of the following**:**

- Line 2B (dedicated bus lane): Adding Line 2B to the existing A Re Yeng network but having the bus operating in a dedicated bus lane. This can be achieved by constructing an additional lane along Lynnwood Road.
- Line 2B (mixed traffic): Adding Line 2B to the existing A Re Yeng network but having the bus operate in mixed traffic. This can be achieved by converting a mixed traffic lane

The Line 2B properties of these options are detailed in Table 2.

Table 2: Route properties for Line 2B possibilities.

Route	**Description**	**Speed (km/h)**	**Headways (minutes)**
Line2B	Trunk line between Hatfield and Menlyn. Operating in a dedicated bus lane.	25	7
Line2B	Trunk line between Hatfield and Menlyn. Operating in mixed traffic	15	7

Any combination of all the feeder route options can then be chosen. All feeders have operating speeds of 15km/h and have headways of 15 minutes. Maps are attached.

Appendix B: Pre-workshop Survey

Part 1 Basic Information

1. Personal Information			
1A	What is your gender?	1 = Female 2 = Male 3 = Prefer not to tell	
1B	What is your occupation?		
1C	What is your highest level of education?	1 = Grade 12 2 = University degree/diploma 3 = Masters degree 4 = Doctoral degree 5 = Other (specify):	
1D	How much (roughly) do you spend on transport each month?	R	
2. Household information If you are a student, household refers to your original household.			
2A	How many people are there in your household?		
2B	How many children (under 18 years old) are there in your household?		
2C	What is your total household **monthly** income?	1 = R1 – R1 600 2 = R1 601 – R12 800 3 = R12 801 – R38 400 4 = R38 401 – R102 400 5 = R102 401 – R500 000 6 = R500 001 or above 7 = No income 8 = Don't know 9 = Prefer not to tell	
2D	If you are a **student**, what is your **monthly** income, **excluding** the income spent on rent? Sources of income could include: allowance from parents, bursary stipend, income from tutoring, income from a part-time job etc.	1 = R1 – R1 000 2 = R1 001 – R3 000 3 = R3 001 – R5 000 4 = R5 001 – R6 000 5 = R3 001 – R5 000 6 = R5 000 or above 7 = No income 8 = Don't know 9 = Prefer not to tell	

3. Transport

3A	How many cars does your household have access to?	

3B	How often do you use the following modes to travel between home and work on a daily basis or to complete your most frequent trip? (Circle your response)					
	Walk	Never	Almost never	Sometimes	Almost always	Always
	Bike	Never	Almost never	Sometimes	Almost always	Always
	Car (as driver or passenger)	Never	Almost never	Sometimes	Almost always	Always
	Gautrain	Never	Almost never	Sometimes	Almost always	Always
	Metrorail	Never	Almost never	Sometimes	Almost always	Always
	Tshwane Municipal Bus	Never	Almost never	Sometimes	Almost always	Always
	BRT (A Re Yeng)	Never	Almost never	Sometimes	Almost always	Always
	Minibus Taxi	Never	Almost never	Sometimes	Almost always	Always
	Uber	Never	Almost never	Sometimes	Almost always	Always
	Other (specify mode and frequency):					
3C	Think of the eldest child (under 18) who lives in your household. How often does this child use the following modes to travel between home and school on a daily basis? (Circle your response). If you are the eldest child in your household, ignore this question.					
	Walk	Never	Almost never	Sometimes	Almost always	Always
	Bike	Never	Almost never	Sometimes	Almost always	Always
	Car (as driver or passenger)	Never	Almost never	Sometimes	Almost always	Always
	Gautrain	Never	Almost never	Sometimes	Almost always	Always
	Metrorail	Never	Almost never	Sometimes	Almost always	Always
	Tshwane Municipal Bus	Never	Almost never	Sometimes	Almost always	Always

	BRT	Never	Almost never	Sometimes	Almost always	Always
	Minibus Taxi	Never	Almost never	Sometimes	Almost always	Always
	Uber	Never	Almost never	Sometimes	Almost always	Always
	Other (specify mode and frequency):					
4. <u>Public Participation</u>						
4A	Over the past year, roughly how many public planning meetings (e.g. Integrated Development Plan community engagements) have you attended?					
4B	At how many of these did you learn new things about planned projects?					

Part 2 Pre-workshop Perception and Attitudes

1. <u>Project understanding</u> After the introduction, please tell us to which degree you agree with the following statements.			
1A	I know the public transport projects presented.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
1B	I can describe the **features** of the proposed public transport projects to my friends.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
1C	I can describe the **impacts** of proposed public transport projects to my friends.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
1D	I have enough knowledge to advocate for/against the proposed public transport projects.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	

2. Transport understanding
Before using CoAXs, which of the following do you think should be prioritized when introducing public transport improvements? Indicate the ranking from 1 to 5, where 1 is the most important and 5 is the least important.

Transport Priorities	Ranking (1-5)
Travel time savings (alleviating congestion)	
Affordability and equity	
Safety	
Reliability	
Environmental impacts	
Other (Please specify):	

3. Accessibility understanding
Considering accessibility as the ability of a person, at a given place, to reach desired destinations or opportunities, which of the following destinations do you think are of importance when measuring accessibility? Indicate the ranking from 1 to 5, where 1 is the most important and 5 is the least important.

Activities	Ranking (1-5)
Healthcare facilities (hospitals, clinics etc.)	
Jobs	
Educational institutions	
Green spaces	
Supermarkets and farmers markets	
Other (Please specify):	

4. Scope of impact
After the introduction, what impact do you think the two scenarios of expanding A Re Yeng between Hatfield and Menlyn will have on the following individuals or groups?

			Dedicated bus lane	Mixed Traffic
4A	Yourself	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		

4B	Your neighbourhood	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4C	Other neighbourhoods	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4D	Your city	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4E	Pedestrians	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4F	Cyclists	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4G	Private vehicle users	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4H	Public transport users	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4I	People with disabilities	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
5. Enthusiasm Before using CoAXs, to what extent do you agree with the following statements?				

5A	The proposed Line 2B BRT will be effective at improving transportation in the city.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
5B	The proposed Line 2B BRT will help advance important broader urban goals (e.g. housing, education).	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
5C	I would be willing to use the proposed Line 2B BRT to commute.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
5D	I would be willing to let my children use the proposed Line 2B BRT to commute.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
5E	I am willing to advocate for the proposed Line 2B BRT.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
5F	Understanding accessibility is key to public policy making.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
5G	Understanding accessibility is key to encouraging discussion around the impact of transportation projects.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	

Appendix C: Post-workshop Survey

Part 3 Post-workshop Perception and Attitudes

1. Project understanding After using CoAXs, please tell us to which degree you agree with the following statements.			
1A	I know the public transport projects presented.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
1B	I can describe the **features** of the proposed public transport projects to my friends.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
1C	I can describe the **impacts** of proposed public transport projects to my friends.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
1D	I have enough knowledge to advocate for/against the proposed public transport projects.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	

2. Transport understanding After using CoAXs, which of the following do you think should be prioritized when introducing public transport improvements? Indicate the ranking from 1 to 5, where 1 is the most important and 5 is the least important.	
Transport Priorities	**Ranking (1-5)**
Travel time savings (alleviating congestion)	
Affordability and equity	
Safety	
Reliability	
Environmental impacts	
Other (Please specify):	

3. **Accessibility understanding** Considering accessibility as the ability of a person, at a given place, to reach desired destinations or opportunities, which of the following destinations do you think are of importance when measuring accessibility after using CoAXs? Indicate the ranking from 1 to 5, where 1 is the most important and 5 is the least important.	
Activities	**Ranking (1-5)**
Healthcare facilities (hospitals, clinics etc.)	
Jobs	
Educational institutions	
Green spaces	
Supermarkets and farmers markets	
Other (Please specify):	

4. **Scope of impact** **Line 2B Trunk** After using CoAXs, what impact do you think the two scenarios of expanding A Re Yeng between Hatfield and Menlyn will have on the following individuals or groups?				
			Dedicated bus lane	**Mixed traffic**
4A	Yourself	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4B	Your neighbourhood	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4C	Other neighbourhoods	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		

4D	Your city	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4E	Pedestrians	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4F	Cyclists	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4G	Private vehicle users	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4H	Public transport users	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		
4I	People with disabilities	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive		

Line2B Feeders								
4J	After using CoAXs, what feeder or combination of feeders do you think will have the most impact? Choose a **maximum of 3** feeders.	F1	F2	F3	F4	F5	F6	None

What impact do you think your selected feeder system for Line 2B will have on the following individuals or groups?

4K	Yourself	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive	

4L	Your neighbourhood	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive	
4M	Other neighbourhoods	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive	
4N	Your city	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive	
4O	Private vehicle users	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive	
4P	Public transport users	1 = Very negative 2 = Negative 3 = None 4 = Positive 5 = Very positive	
5. Enthusiasm After using CoAXs, to what extent do you agree with the following statements?			
5A	The proposed Line 2B BRT will be effective at improving transportation in the city.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
5B	The proposed Line 2B BRT will help advance important broader urban goals (e.g. housing, education).	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
5C	I would be willing to use the proposed Line 2B BRT to commute.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	

5D	I would be willing to let my children use the proposed Line 2B BRT to commute.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
5E	I am willing to advocate for the proposed Line 2B BRT.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
5F	Understanding accessibility is key to public policy making.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
5G	Understanding accessibility is key to encouraging discussion around the impact of transportation projects.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
6. Usability Please give us feedback based on your experience using CoAXs.			
6A	I found CoAXs easy to use.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
6B	I think the functions in CoAXs were well integrated.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
6C	I would imagine that most people would learn to use CoAXs very quickly.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
6D	I felt very confident using CoAXs.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	

7. Usefulness Please give us feedback on how you think CoAXs can be useful in the future.			
7A	I was able to get answers to the questions I had from CoAXs.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
7B	The results I got seemed unrealistic or implausible.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
7C	CoAXs distracted people from conversation.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
7D	CoAXs provided a useful common ground for all participants to work together.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
7E	CoAXs helped raise important issues for discussion.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
7F	CoAXs prompted me to think about alternatives for my own commute/travel.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
7G	CoAXs helped me imagine what commute/travel is like for others.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	
7H	I would imagine CoAXs to be a useful tool in future public meetings about proposed public transport improvements.	1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree	