Participatory Augmented and Virtual Reality: A comparative case study recognising its viability in citizen participation

by

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Author's Declaration

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

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Abstract

With technology's growth in recent years, governments have begun adopting new methods of citizen participation into decision-making. New technologies require a deep analysis of their implementation, to understand and identify how it constrains or enables participation. One such technology is augmented and virtual reality (AR/VR). First built in the 1950s, this technology has seen rapid advancements over the past decade, and is now adoptable as a tool in decision-making. Alongside the rise of this technology, few studies have characterised its ability as a participatory tool, which are absent of a general framework for governments to follow. Research has shown the potential upsides and failures of AR/VR, but not sufficiently to determine its impact in citizen participation. This research aims to address this gap in research by exploring cases across North America, in determining the benefits and challenges of participatory AR/VR, and addressing its viability in citizen participation.

To meet the research objectives, five cases were identified, combining in six interviews of nine individuals involved in the implementation of the technology. These participants were affiliated with the creation of the renderings, adopting of the technology, and involved in the participatory meetings. The semi-structured interviews revealed that AR/VR characteristics allow it to logically perform well as an urban planning tool, due to its realism, proactive approach to communication, and educative nature in explaining contextual information, but lacks the ability for it to function as a participatory technique, meaning it is unviable in citizen participation. This was determined by addressing characteristics of success which were clouded by shortcomings of the technology. These insights yielded requirements for participatory AR/VR to progress, which involves the adoption of a framework that uses citizen co-production, realism, interactivity, immersion, gaming engines, and real-time feedback curation. It was concluded that AR/VR must follow a distinct structure to function as a viable participatory technique. If it strays away from a framework, it loses its participatory capabilities and simply becomes a visualisation beneficial in disseminating complex contextual information. Overall, this study demonstrates AR/VR has potential in citizen participation, and expresses a set of best practices recommended for future government adoption.

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P.S. Please get vaccinated.

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Chapter 1
Introduction

Addressing issues of public concern as an individual or group of citizens is one of the many ways to describe citizen participation. Participating in these concerns is a requirement in democracy (Dahl, 1989) and makes it possible for self-directed change. Citizen participation is centered on citizens engaging in political and community problems, therefore influencing communal change, and creating social capital. Social capital is important in the functioning of society, it is relationships made between those living in certain communities, allowing it to be healthy and functioning. Not only is social capital important, but the power of collective action supported through citizen participation empowers society and opens democracy. This effectiveness makes citizen participation important and integral to an active democratic system. With the growth of technology, the tools enabling participation has changed. It has allowed for citizens to participate through means of online applications, surveys, social media, interactive web-maps, and smartphones. Newer technologies that incorporate 3D visualisations and computer graphics has allowed citizens to gain knowledge and understandings of complex urban issues through immersive means.

In Canada and the U.S., citizen participation is required by law to be incorporated in the planning process. For a Canadian context, participation has roots in some of the earliest examples of citizen power in North American planning. The Stop Spadina grassroots movement of the late 1960s is an effective example of citizens creating a committee to raise concerns, opinions, and most importantly, their voice, to act against a planned expressway in Ontario, eventually leading to the project's demise. Jurisdictional levels of government are not limited by citizen participation. The Canadian Government has seen multiple attempts at engaging citizens in decision-making, one of the early examples being the Spicer Commission (1990-91). This Commission used different participatory and engagement methods to inform the federal government on citizens opinions of the future of Canada (Longo, 2017; Spicer, 1991). Compared to federal initiatives, municipal and local level participation are more commonplace. Cities have created their own strategies on how to incorporate citizen engagement into decision-making, by developing methods described in a city's Master Plan or establishing a separate committee which oversees the city's incorporation of such strategies. The intention is to incorporate citizen's opinions, knowledge, and expertise into decision-making. During the COVID-19 pandemic that limited in-person interaction, many cities in Canada built online platforms, allowing citizens to participate from home.

1.1 Issues in Participation

The most common and well-known way of participating in a political process is voting. It is, undoubtedly, the most popular and a fundamental aspect of democratic theory. Voting allows for citizens to engage on the agreeing or disagreeing with certain political ideologies by casting a vote. While voting is the basis for any democratic nation, it is limited by the quality of engagement. Considering voting is the easiest way to engage in decision-making, there is still a lack of political participation in voter turnout. This issue, may it be lack of interest, the belief that citizen voices are unheard, or a sense of distrust towards political processes (Henn & Foard, 2012; Henn & Weinstein, 2006), trickles down into more specific civic governance processes. Moving forward is the discussion on finding and understanding new ways to engage citizens in decision-making and political processes.

Arnstein's Ladder of Citizen Participation (1969) is an example focused on addressing the limited use of citizen's contributions in public planning decision-making. While Arnstein's Ladder is product of its time, written during the Vietnam War when U.S. citizens held little power, it still maintains certain truths. Arnstein tries to understand citizen contribution by delegating participation into eight rungs on a ladder. By doing this, she defined how participation is formed from nonparticipation to complete citizen control. Each rung in the ladder identifies certain participation techniques that allow for unique understandings on how citizens participate. Arnstein delegates society into two categories: the haves and have-nots. The current participatory system is one where citizens have a modest degree of power through means of consultations. Consequently, the consultation process has been long researched and scrutinised, equally for its lack of participation and tokenism in decision-making (Innes & Booher, 2004). Moving forward is understanding technology's role in citizen contributions, what this means for participation, and how technology could influence decision-making (Janssen & Zuiderwijk, 2014; Johnson, Robinson, & Philpot, 2019).

Since citizen participation leads to positive outcomes, it is important to have valid and thoughtful feedback. In the past decade, there has been an emergence of research focusing on the implementation of technologies in decision-making and its affect on participation. Certain cases have seen technology reform the interaction between citizen and government (Desouza & Bhagwatwar, 2014; Johnson, 2017) and created a shift from e-government to we-government (Linders, 2012). Some literary themes from this shift focus on the enabling and disempowerment of individuals or groups of citizens (Ghose, 2001), and how technology shapes citizen's perspectives (Johnson et al., 2015). While governments might believe adding technology to the participatory process benefits everyone, research has found citizens are excluded or marginalised due to the type of technology introduced (Buss, Guo & Redburn, 2006), and contributions reduce the intricacies of complex understandings to simple transactions, also referring to the labelling of citizens as data points (Johnson et al., 2019; Linders, 2012; Mora, Deakin, & Reid, 2019; Mossberger, Wu, & Crawford, 2013). Furthermore, technology may not necessarily change the status-quo of participation, increase inclusivity, or change the nature of participation (Desouza & Bhagwatwar, 2014; Johnson et al., 2019). Knowing how to implement citizen participation is a struggle that has grappled researchers, governments, and academics for decades, with some labelling it as a wicked problem (Wexler, 2009). Adding technology to this process further challenges our understanding of citizen participation. Johnson et al. (2019, p. 3) made a call for further research on "how technology intervenes in the process of citizen participation", which this study aims to address in investigating augmented and virtual reality (AR/VR).

1.2 Augmented and Virtual Reality

We have seen a massive leap forward in augmented and virtual reality type technologies in the past decades. They are becoming commonplace in households and professional environments because of their multi-disciplinary nature. Accessibility to this technology has increased as most people have AR/VR capable smartphones, essentially bringing this technology to a broader audience. These technologies function with the requirement of a 3D rendering, scene, model, or environment. These can be based on reality or fictional, and are built using computer software. For the purpose of my thesis, I will be using AR/VR throughout.

AR/VR are not new technologies, each have a long history of development after the mid twentieth century. AR and VR are meant to enhance what we see, giving us a new perception of our real world. While both technologies use computer-generated renderings, there are differences. Carmigniani and Furht (2011, p. 342) defined AR as being "a real-time direct or indirect view of a physical real-world environment that has been enhanced/*augmented* by adding virtual computer-generated information to it". AR superimposes computer-generated information on real-world elements, most often using the camera on smartphones, or headset devices. A well-known example of

AR technology is Pokémon GO, a mobile application which uses smartphone cameras to place virtual Pokémon on the surface of the real-world. Augmented reality uses the user's real surrounding environment by placing virtual objects on-top of it, which can then be interacted with. With certain AR applications, users can touch the superimposed 3D elements, manipulating them virtually in the real-world space.

Virtual reality is a complete virtual experience of the world. VR, as defined by Steure (1993, p.76), is "as a real or simulated environment in which a perceiver experiences telepresence". Steure refers to telepresence as any form of hardware allowing you to perceive an environment. With this technology, smartphones with Google Cardboard or true VR devices, such as the Oculus Rift, HTC Vive, Valve Index, etc., are placed over a user's eyes, immersing them into a virtual space. In comparison to AR, which has objects superimposed over real-world elements, VR is an entirely virtual rendering, meaning every element the user is seeing is in a virtual environment. With VR systems, they can reproduce real-world sensations, by including audio and the user's physical movements. Further, the user can interact with the virtual environment, by moving around or manipulating items. However, a full interactive experience is only possible with more expensive VR systems which include hand-held peripherals or tracking sensors in the devices.

1.3 AR/VR in Urban Planning

City planners have used AR/VR to show citizens accurate and realistic visualisations of proposed buildings, roads, zoning, developments, and policies. The intention is to transform these complex changes to an understandable scale, where non-professional citizens can identify urban intricacies. The importance of governments introducing new and unique ways to involve citizens should not be understated. There is a constant absence of participation occurring in our required participatory democracy. Finding new ways to engage citizens is necessary to continuously improve what exists. Research indicates this reality technology affects and increases participation, and is realistic to the point that the quality of feedback changes (Al-Kodmany, 2002; Allen, Regenbrecht, & Abbott, 2011; van Leeuwen, Hermans, Jylhä, Quanjer, & Nijman, 2018). AR/VR, in general, has been mentioned to aid the process of obtaining detailed contributions (Al-Kodmany, 2002; Heldal, 2007). 3D visuals used in and outside a virtual device are impactful on converting abstract data to the citizen in a more understanding way (Al-Kodmany, 1999; Wanarat & Nuanwan, 2013). From a planner's perspective, it allows them to be a mediator in decision-making by showing different scenarios with relative flexibility and being proactive to civic discussions by addressing all options before development occurs (Appleton & Lovett, 2005). Introducing a new unique technology for citizens to experience generates trust between citizens and those who represent them in government positions. It is the willingness to try something new that could benefit citizen-government relationships.

The true nature this technology offers in terms of participation needs to be further researched. Including AR/VR renderings in a public process can be time consuming, expensive, and disruptive (Al-Kodmany, 2002; Heldal, 2007; van Leeuwen et al., 2018). Wearing a head device forces the user to be alone, lacking face-to-face interaction that is sometimes overlooked in participation processes (Al-Kodmany, 2001b, 2002; Heldal, 2007). At times, citizens using AR/VR focus on the glamourous parts of the rendering, rather than the details that should be observed, mainly due to a lack of hands-on ability (Al-Kodmany, 2002; Heldal, 2007). If there is a lack of realism, the citizen can sense a dissociation between what is virtual and reality, whereas too realistic of a scene can feel off-putting or abstract (Herbert & Chen, 2015; Salter, Campbell, Journeay, & Sheppard, 2009). However, realism in an AR/VR environment has been found to conceptualise complex project information, so citizens can understand what is being proposed (Al-Kodmany, 2002). With other 3D technologies, there has been caution in deciding when and how to apply it, to elicit valid responses (Appleton & Lovett, 2005; Lange, 2005). Other new technologies adopted into the citizen participation and engagement, have been found to give negligible change on the feedback being offered and has shifted what it means to participate in a civic process (Desouza & Bhagwatwar, 2014; Johnson et al., 2019; Mora et al., 2019).

Although there is a small sample size of research on AR/VR in participatory process (Al-Kodmany, 2001b, 2002; Allen et al., 2011; Drettakis et al., 2021; Gill & Lange, 2015; Heldal, 2007; Schall et al., 2009; Stahre Wästberg, Tornberg, Billger, Haeger-Eugensson, & Sjöberg, 2013; van Leeuwen et al., 2018), no research has been done on comparing existing cases. There is an opportunity to provide a thorough understanding of what is beneficial from adopting participatory AR/VR, challenges in its implementation, commonalities across geographic boundaries, and constraints. This research addresses this gap in literature by comparing existing case studies across North America, to determine the viability of the technology in citizen participation. In doing so, this study establishes characteristics and how they impact AR/VRs application in citizen participation. Finally, a framework of best practices is proposed best exemplifying the potential of participatory AR/VR.

1.4 Goal and Objectives

The goal of this thesis is to assess the use of participatory AR/VR within citizen participation. Furthermore, employing a comparative case study form of analysis, this thesis investigates commonalities, benefits, challenges, constraints, and potentials faced by the use and adoption of AR/VR as a participatory tool. This thesis will assess the viability of adopting this form of technology, by determining its place in citizen participation. The findings from this study present the current ability of participatory AR/VR, and its characteristics which are successful or cloud its implementation. Finally, the research will serve as guidance in determining how best to adopt AR/VR in the form of a framework based on potential criteria.

To achieve these goals, the following question will be answered:

> **RQ**: What are the benefits and challenges of augmented/virtual reality being used as a participatory tool in citizen participation?

1.4.1 Research Objectives

The following objectives are used to layout the structure of the thesis in answering the research question:

i. identify projects that have adopted AR/VR for citizen participation,
ii. employ a comparative case study to understand people's motivations, experiences, and opinions in working with AR/VR,
iii. determine the benefits and challenges of AR/VR as a participatory tool,
iv. recognise the technology's viability in citizen participation and urban planning, and
v. outline requirements demonstrating the best practices of participatory AR/VR.

1.5 Thesis Outline

This thesis is one manuscript focusing on understanding the technology of AR/VR as a participatory tool in citizen participation. It is structured in the following manner:

Chapter 1 introduces the research topics of citizen participation and AR/VR, and outlines the question and objectives of the thesis.

Chapter 2 establishes a literature review on citizen participation in urban planning, it identifies certain participation methods and tools, understands how technology influences participation, and characterises AR/VR from existing research.

Chapter 3 describes the methodology used in selecting the cases, collecting the data, analysing the interviews, defines the comparative case study, and introduces the cases.

Chapter 4 reviews the results from the interviews, organised by main themes, and includes direct quotations from respondents.

Chapter 5 discusses the results and compares them to literature outlined in Chapter 2, in doing so, discovers that AR/VR is a beneficial urban planning tool, unviable in as a participatory tool, requires growth and a framework to be useful in citizen participation, and addresses the study's limitations.

Chapter 6 concludes the thesis by addressing the overarching findings, the technology's place in citizen participation, and future research in participatory AR/VR.

Chapter 2
Literature Review

2.1 What is Participation? Definition, purpose, and debate

In 1965, Davidoff introduced advocacy planning. His argument structured on the notion that planning must fundamentally change to *advocate* the interests of the poor and powerless. At the time, this was an opposing view to conventional top-down planning. Building upon this idea is the foundational work by Arnstein (1969) on understanding participation and categorising society within certain participatory realms. She created a ladder which represents the power citizens hold within the decision-making process, where manipulation is the lowest rung in terms of participation, and citizen control is the highest form of citizen power. Regarding traditional participation, Arnstein's ladder is an important contribution to academic and practical literature. This is because of its ground-breaking nature in being an early piece of research trying to represent the participation structures in the U.S. Arnstein pushed forward the discussion on citizen participation, seamlessly opening this topic to different academic fields outside of planning, such as tourism (Jordan, Vogt, Kruger, & Grewe, 2013; Okazaki, 2008), and health policy (Tritter & Mccallum, 2006). While Arnstein's work is a classic piece of literature, it faces criticism. Collins and Ison (2009) compared existing critical literature on this ladder, finding areas of concerns. One criticism is how Arnstein's participation is hierarchical, where the goal of participation is to have citizen control, something that does not always align with people's reasons for engagement. They concluded their research by addressing how Arnstein's depiction of participation is explicitly associated with power, limiting progression within her collective process.

The discourse on citizen participation has had a long-contested contextual definition and purpose. Day (1997) wrote about citizen participation within planning as a contested concept. She argued this contention results from an untidy amount of literature that does not properly discuss "what participation looks like in practice, and what exactly citizen participation is supposed to accomplish" (p. 422). An early example of this contention is expressed by Glass (1979), where he opens his paper deeming an "overgeneralization" of the term citizen participation, where the term and definition do not offer insight on "how participatory efforts might be structured or what might be expected of them in terms of results" (p. 180). He further argued the purpose of citizen participation is delegated into two objectives. The first objective (administrative perspective) is where citizens are consulted "in order to ensure that a citizen view is considered along with a staff view in planning" (p. 182). The second (citizen perspective), allows the opportunity for citizens to become actors within decision-making, to "yield input that is representative of the entire community" (p.182). Glass' contextual definition differs from Arnstein's which draws more on the redistribution of power than the objectives citizen participation serves.

Newer definitions in this debate aim to be more detailed and wide ranging in disciplines. Burby (2003, p. 34) described desirable citizen involvement in the making of city plans because "citizen involvement can generate information, understanding, and agreement on problems and ways of solving them". Involvement is seen as a technique to reduce opposition towards plans if citizens are properly included. Hawkins and Wang (2012, p. 8) integrated the term governance into their conceptualisation of citizen participation. Their description involved municipal government interactions with "local organisations for economic development, environmental protections, and to achieve social equity goals". Roberts' (2004) extensive review on the definition of citizen participation, uses the shared power and decision-making described by Arnstein and the legality behind its origin, to build this working definition: "the process by which members of a society share power with public officials in making substantive decision and in taking actions related to the community" (p. 320).

Just as important to the definition of citizen participation, is its purpose. Glass' definition and objectives have been categorised and examined earlier in this section, and his purposes are further worked upon by Innes and Booher (2004). They described five purposes of participation (p. 423-4): 1) for decision makers to understand the public's opinions, 2) improve decisions by incorporating local knowledge, 3) advancing fairness and justice, 4) achieving legitimacy for public decisions, and 5) participation is required by law. Two new purposes are expressed as an evolution through collaborative practices, building civil society and self-organising polity capable of addressing wicked problems (Rittel & Webber, 1973). Bryson, Quick, Slotterback, and Crosby (2013) built a guideline for public participation that intendeds to be cross-disciplinary and evidence based, and designed a structured plan recognising the values of participation. Outlined in this design structure are numerous purposes of public participation identified from a rigours literature review process, where "multiple purposes may be served by a single process, and purposes may change as the public participation process unfolds" (p. 26). They are meant to serve as a tool for "practitioners to articulate purposes and consider how to fulfill them over the course of the decision-making process" (p. 27). Considering these purposes, citizen's involvement in planning is significant for proper and better decision-making (Bryson et al., 2013; Burby, 2003).

Quick and Bryson (2016) argued, for any purpose to succeed and realise a powerful participation process, there are several governance factors that effect the nature of participation. These are outlined as legitimacy, diversity and inclusion, and expertise. These factors are built upon Fung's (2006) *democracy cube*, where three participation dimensions are put into a three dimensional space, intending to understand participatory mechanisms and governmental arrangements. These themes are a result of the complexities challenging participation and governance processes. If these factors are met and the purposes are fulfilled, positive effects of citizen participation surface. Citizens included in decision-making can express their local knowledge that can lead to the avoidance of problems not aware to experts (Burby, 2003; Renn, Webler, Rakel, Dienel, & Johnson, 1993) and participation articulates greater variations of views (Fung, 2006). Arnstein (1969) argued the benefits of engagement lead to the formation of social capital in civic communities and a greater education in political affairs. In the case of Roberts (2004, p. 323-4), she brings together democratic theory and citizen participation to suggest benefits of involvement are developmental, educative, therapeutic and integrative, legitimating and protective of freedom. From a governance standpoint, Innes and Booher (2010) discussed the benefit of citizens actively engaging as belonging in the ownership of a problem and its solution.

While there are clear positives to introducing and using citizen participation within decision-making processes, certain scholars are inclined to debate these benefits. Irvin and Stansbury (2004) criticized the advantages and disadvantages of citizen participation from the viewpoint of the citizens and government. They found the main disadvantages towards citizen participation is the cost, difficulty of diffusing citizen goodwill, complacency, representation, lack of authority, power of wrong decisions and selfishness. Although these are clear disadvantages, Irvin and Stansbury (2004) organised these problems as a lack of effective structuring to the participation process. They addressed several considerations that are described as "ideal conditions for implementation of enhanced citizen participation" (p. 62). These considerations are strategies employed to achieve significant outcomes in participation processes for effective community decision making. Roberts (2004) agrees with the disadvantages by emphasising certain problems. The problems of participation Roberts (2004) highlights are: participation is based on a false notion (humans are either passionate or apathetic), inefficient (too complex, expensive and slow), politically naïve (citizens choose organisations that provide security, even if it brings about hierarchy and control), unrealistic (citizen involvement is a luxury, it requires skills, resources, money, at times things many people do not have), disruptive (can destroy social stability, and lead to low self-esteem, alienation and distrust if participation is not fulfilled), and dangerous (adoption of antidemocratic policies that value stability over uncertainty).

The healthy debate on the definition and purpose of citizen participation has made it possible for criticisms to be found outside of participation and within planning systems. Innes & Booher (2004) identified that participation in the U.S. lacks genuine content, being described by the authors as "the citizen's role is to react" (p. 425), referring to the citizen's responsibilities are simply reactionary to the government's policies. While the participation process is legally required, in most cases the citizen is simply a token participant through consultations. Innes & Booher's (2004) paper tried to understand this tokenism of participation, to identify why and how public participation must change at the dawn of a new century, reflecting on the stagnant role of citizens in planning over past decades. Considering their investigation, they concluded public hearings, and review and comment procedures do not work, requiring an overhaul of the consultation process. Resulting from this stagnation and tokenism was the creation of the International Association of Public Participation (IAP2). IAP2 created a code of ethics and core values centered on the idea that everyone who is impacted by a decision has a right to be involved in that process. The principles outlined in their code of ethics intends for public and stakeholders to uphold their respective duties, to maintain trust, openness, and commitment, to maintain integrity in the public participation process. This association aims to show what public engagement is meant to be, moving forward from decades of tokenism.

2.2 The Deconstruction of Decision-making: Rebuilding theory and practice

Davidoff (1965), Gans (1969) and later Day (1997) critiqued planning for its elitist structure focused on benefiting societal elites and reinforcing top-down rationales, rather than strategic planning that involves participation. Already cited is the work by Davidoff (1965) on the introduction of advocacy planning in conventional urban planning. Davidoff said modernist planners informed their decisions on a scientific rational and chose specific citizen participation to legitimise their ideas, to alienate themselves from community stakeholders. The downfall of this planning structure came at the time of urban renewal, which verified the vast complaints towards the top-down, expert driven conventional planning. Fainstein (2000) labels this past planning structure as the rational model, which promoted scientific data and Corbusian approaches for physical solutions to urban deterioration.

2.2.1 Communicative Planning

The communicative model is the embedding of Habermasian communicative rationality and American pragmatism (Feinstein, 2000) in the theoretical understanding of how contemporary planning has shifted. Habermas' communicative rationality considers the role of a planner as an intermediator and negotiator amongst social groups and stakeholders. Healey (1993) explained communicative rationality intends for mutual understanding being enabled by communication. Habermas' theory allows for an open space of communication, where making decisions is influenced by dialogue and conversations. This post-structuralist reality is meant to achieve a consensus through conversation amongst all parties involved. In planning, those who are participating, according to communicative rationality, are freely able to express their opinion, and not be influenced by government and social power structures. This rationale became prominent in urban planning because of its critique on power structures and the notion that citizens no longer required the planner to use "scientifically formulated empirical knowledge to guide actions" (Healey, 1993, p. 239), in the previous top-down system. Rather, citizens saw a place for planners to be insightful when needed "but primarily being sensitive to points of convergence" (Fainstein, 2000, p. 454).

This model has had different terms throughout literature. Innes (1995) originally used the term communicative action, yet subsequently changed to collaborative rationality/planning (Booher & Innes, 2002; Harris, 2002; Healey, 1997; Innes & Booher, 1999) which was first developed by Healey (1993; 1997). Other scholars have named it argumentative planning (Fischer & Forester, 1993) which later shifted to communicative practice (Fischer & Gottweis, 2012). While researchers have created different names, the models are grounded in similarities. Communicative planning intends to represent a required change in planning, yet some scholars believe it has shortcomings. Fainstein (2000, p. 455) illustrates the communicative model "should not be faulted for its ideals of openness and diversity". Others have critiqued the model in how it addresses power (Allmendinger & Tewdwr-Jones, 2002), such as the uneven power structures between planner and citizen, where even in this model planners have the ultimate influence on decision-making.

2.2.2 Citizen Co-production

Citizen co-production is the truly inclusive nature of citizens involved in decision-making. Where communicative planning falters, co-production excels and builds upon its disappointment. Joshi and Moore (2004, p. 40) define co-production as "the provision of public services through regular, long-term relations between state agencies and organised groups of citizens, who both make substantial resource contributions". Co-production addresses economic, political, and social inequities that impact decision-making (Rosen & Painter, 2019). Compared to communicative planning, it brings attention to the power dynamics of decision-making, where citizens and planners are equally in control of the process. Communicative planning can be argued as a heightened form of consultation which can potentially include collaborative practices. While citizens are freely open to express their opinions and knowledge through an open agora, planners control and implement the final decision. Further, communicative planning has been criticized in literature for its inability to address and dismantle power structures (Allmendinger & Tewdwr-Jones, 2002; Booher & Innes, 2002; Fainstein, 2000; Fischer & Forester, 1993; Healey, 2003; Innes, 1995). Co-production analyses the communicative rationality's deficiencies, in creating a sustainable method of citizen power. Citizen power comes from Arnstein's (1969) famous ladder, however, co-production is based on shared-power over her citizen authority.

Ostrom (1996) based co-production on the truth that citizens improve public goods by providing local knowledge. What allows co-production to exemplify equality is through citizen participation. Rosen and Painter (2019, p. 339) argued instead of viewing citizens as passive consumers, "co-production re-envisions and legitimises citizens as active participants and knowledge holders […] through decision-making". This powers citizens to become integral in decision-making through decentralising governance. In citizen participation, Horne and Shirley (2009) described co-production as allowing citizens to have a greater role in decision-making, by including their feedback, concerns, ideas, and expertise. A model of co-production incorporates citizens to equal partners in decision-making and encompasses community connectedness. In planning, Albrechts (2012) explained that traditional spatial planning was unable to tackle current and future problems. It was found applying strategic co-production would change the approach to creating plans and policies, being an open and equitable way to solve communal challenges.

From Rosen and Painters (2019) study on the Coachella Valley, they realised planners must recognise their power in the process, creating a necessity to go beyond collaboration. Linders (2012) argued early examples of co-production were limited by the ability of citizens to effectively coordinate actions and self-organise. With the introduction of internet-based tools, interaction and communication through an online platform "enabled co-production on an unprecedented scale" (Linders 2012, p. 446). Literature stresses the importance of co-production in decision-making, labelling it as a shift in citizen-government relationships. Sieber and Johnson (2015) described the co-production of open data promotes transparency, increases trust, provides a check on government activities, and promotes social connectedness. Where citizens were once a passive consumer, in co-production, they are active partners in decision-making, as Linders (2012) calls it: We-Government.

The deconstruction of decision-making reflects upon movement from tokenism to shared citizen-power, addressing two models which were built from top-down planning structures. Considering communicative planning, while the critiques on its theoretical and power deficiencies are apparent, there has been successful implementation over the past decades of its conception (Booher & Innes, 2002; Fainstein, 2000; Harris, 2002; Healey, 2003; Innes & Booher, 1999). This model emphasises openness of freely expressing opinions, and in some cases, is collaborative between citizen and government. Collaboration involves citizens, professionals, stakeholders, and administrators to problem solve and build strong relationships (Callahan, 2007). For co-production, it is not limited to urban planning, but other areas in governance, such as smart city applications, open data initiatives, and environmental sustainability (Linders, 2012b; Rosen & Painter, 2019; Sieber & Johnson, 2015; Zuiderwijk, Choenni, Meijer, & Sheikh Alibaks, 2012). This model is built upon the mistakes of communicative planning and adheres to equitable foundations of participation and engagement, through the shared power between citizens and governments.

2.3 Models and Methods of Citizen Participation

The labelling of interactions between citizen and government in citizen participation can be placed into modelled categories. Callahan (2007, p.1187-1188) delineates them into eight models of interactions, from citizens as subject/administrator as ruler (authoritarian) to citizen as owner/administrator as employee (citizen control and government as an advisor). Similarly, Arnstein's (1969) ladder represented a model for each rung. Her ladder is a perfect example of different models that facilitate either one- or two-way interactions, from non-participatory manipulation to full fledged citizen power in citizen control. Most often, the administrator or decision-maker is in control of the participatory process. In a North American context, administrators choose which level of citizen participation is to be adopted (based on local legislature) and the participation technique, meaning the government controls public discourse.

Within Callahan's (2007) models are active and passive forms of participation. Furthermore, these models are associated with the way citizens are involved in governance and decision-making. Box (1998) used suggestive terms to described passive participants as freeriders and activists for active participation. While the definition of these terms has changed, Box explained freeriders take a passive view on participation, where the government is entrusted to make the proper decision. Active participation is when citizens have a more active role in decision-making by being informed and engaged. Timney (1998, 2011) uses the terms active, passive, and transitional. Her discussion on active participation is when citizens control the process and outcome, and the government are consultants. For passive participation, governments control and makes decisions, meaning citizens are less informed. The transitional model of participation is a middle ground where citizen and government has shared power in the process, but the citizen's role is usually advisory.

Each model has different ways of collecting feedback and contributions. The different methods of feedback collection, in the traditional participatory setting, has not change drastically. Rarely are new techniques added. These techniques range from structured task forces, workshops and open houses, to individual based participation of surveys and voting (Rowe & Frewer, 2000). Rosener (1975) listed thirty-nine different participation techniques calling it a cafeteria of mechanisms. Rowe and Frewer (2005) found one-hundred different mechanisms used across cases in the U.K. and U.S. While there are numerous different techniques, Rowe and Frewer (2005) found there was a high degree of confusion on how certain techniques should be used to enable effective participation. Depending on the applied technique, it can effectively alter the model of interaction between government and citizen. There is a sizeable amount of literature (Arnstein, 1969; Callahan, 2007; Irvin & Stansbury, 2004; Milbrath, 1981; Richards & Dalbey, 2006; Rowe & Frewer, 2000, 2005; Timney, 2011) categorising participation techniques and identifying their effectiveness. There are good and bad, desirable and undesirable, fair and unfair outcomes based on the mechanism's intended purpose. Rowe and Frewer (2005, p. 263) placed these outcomes into three competencies: public communication, consultation, and participation. Each technique were placed into these competencies, based on what the technique informs in the participation process. They further argued the effectiveness of an outcome is dependent on how the mechanism or technique is applied.

2.3.1 Technology in Participation

The quick rise of technology, Web 2.0 and smart city applications further blurs the dynamics of participatory models and effectiveness of techniques. These new methods are associated with the generation of contributions for civic discussions. With the introduction of technology, how citizens participate is changing from traditional in-person and intentional, to online, mobile and at times uninformed contributions. Cardullo and Kitchin (2019) built a conceptual framework to look at smart city applications in Dublin, Ireland, with further comparisons to Arnstein's ladder. They found citizens were passive and/or active in generating civic discourse. While being passive, the systems in place made citizens simple data-points created by sensors. Gabrys (2014) argued sensors are expressionless contributions, simply created by a computer environment. This means real and genuine feedback is lost when citizens are considered computerised statistics. Cardullo and Kitchin (2019) analysed citizen-government relationships and its role in how the contributions are being created, being intentional (active) or non-participatory (passive). To be an active contributor, they described it as a co-creation and collaboration between citizen and government. However, this active form of participation in a smart city is often owned and run by a third-party. They argued active contributions in smart cities are rooted in a neoliberal conception of citizenship, which leads to market-led solutions and the dismissing of participation grounded in social and political justice. This active and passive form of contribution addresses the change in participation once new or existing technologies are applied.

Johnson et al. (2019) approached citizen-government relationships by conceptualising the interactions of contributions as micro-transactions. They argued transactions shape the way a citizen is involved, directly or indirectly in decision-making and governance. Four transactions of citizens contributions in the smart city were reviewed: type (intentional contribution), tweet (intermediated by third party), tap (convened or requested transaction), and pass (ambient transaction based on movement). They found these transactional modes and citizen-government relationships are impacted by technology. Understanding technology's implementation by government is touched upon by literature as a requirement moving forward, deeming it necessary to investigate how technology could enable or limit citizen participation (Berger, Hertzum, & Schreiber, 2016; Janssen & Zuiderwijk, 2014; Johnson et al., 2019). Johnson et al. (2019, p. 3) mentioned the importance to "begin to frame how specific technologies […] result in changes to citizen-government interactions, intentionally or not". This requirement to present and track changes on interactions altered by technology allows governments to reflect and choose best option scenarios. Rowe and Frewer (2005) deemed technology has a profound role in determining what the mechanism informs in the participatory process. Further, the effectiveness of techniques depends on how it is applied, meaning when technology is adopted, this can modify a technique's purpose and outcome in citizen participation.

2.4 Augmented and Virtual Reality in the Participatory Process

Literature shows AR/VR as a participatory tool enhances the urban planning process (Allen et al., 2011; Piekarski & Thomas, 2001; Sareika & Schmalstieg, 2007; Schall et al., 2009), allows citizens to better grasp and understand complex civic issues (Al-Kodmany, 1999, 2001b; Gill & Lange, 2015; Heldal, 2007; van Leeuwen, Hermans, Quanjer, Jylhä, & Nijman, 2018;. van Leeuwen et al., 2018), and is multi-disciplinary, including architecture, urban planning and design, policy development, and environmental assessments (Axford, Keltie, & Wallis, 2007; Cirulis & Brigmanis, 2013; Stauskis, 2014). Al-Kodmany (2002, p. 199) described the benefits of VR in planning as mimicking "the way people interact with the environment in the real world", so all people, regardless of backgrounds, can communicate in a visual language. AR/VR can have virtual interactivity of physical items through immersion. However, issues arise in adopting this technology for participatory purposes. At times, it can be hard for participants to relate the virtual environment to the real-world, while also tricky to maneuver (Hudson-Smith, Evans, & Batty, 2005), the technology can be costly (Al-Kodmany, 2001b, 2002; Heldal, 2007; van Leeuwen et al., 2018), and there is difficulty using it online and at-home (Heldal, 2007; Hudson-Smith et al., 2005; van Leeuwen et al., 2018). Adopting AR/VR in a participatory process is new and experiencing growth, resulting in a small sample of case-based literature. This section will cover current adaptations of AR/VR in participatory processes.

AR/VR has the uniqueness of being a multipurposed participation tool, with possible at-home and in-person techniques. At-home AR/VR can be described as a citizen owning the tools themselves (this could be a smartphone/VR headset), allowing them to participate by downloading models online (Al-Kodmany, 2001a; Heldal, 2007). Similarities can be drawn between PPGIS and at-home AR/VR. PPGIS is a community-based approach to solving spatial problems through spatial approaches. Most commonly, citizens through grassroot or community groups use spatial tools to empower themselves in decision-making (Schlossberg & Shuford, 2005; Sieber, 2006; Tulloch, 2007). However, at-home AR/VR is understood as a "do-it-yourself" form of participation, where AR/VR visualisations are placed online by governments for individuals to access and give feedback, characteristically different than a community-based approach to spatial problem solving. In certain scenarios, AR/VR technologies can work by incorporating a PPGIS framework. This adoptable method has yet to be tried, as made apparent by no literature on the topic. For it to function, the community would require the necessary means to produce AR/VR visualisations, such as having computing power, technical knowledge on 3D visual production, and AR/VR devices. In literature, the common methods are governments/researchers using AR/VR as a participatory tool to garner feedback from citizens (Heldal, 2007; Kuliga, Thrash, Dalton, & Hölscher, 2015; Leeuwen et al., 2018).

2.4.1 In-person Techniques

For in-person participation, AR/VR is often used in a workshop setting, where citizens are invited to take part in addressing urban issues, projects, development proposals, etc.. Van Leeuwen et al. (2018) used VR as a device to enhance the already existing tools within the workshop setting. VR was incorporated alongside computer renderings for tablets and smartphones, and paper plans and photographs of the neighbourhood. During this study, citizens voted on certain proposals, and found that people were drawn more to VR than traditional visualisations. VR was found to be equally as effective as a participatory tool as its traditional counterparts, and at times elicited better understandings of the proposed plans. However, when accuracy of recall in the environment was discussed, VR had no impact, meaning, VR's immersive nature was not helpful in recalling certain aspects of the rendering. Renderings on a computer had similar recall to those viewing it in an AR/VR environment. Al-Kodmany's (2002) discussed VR use from multiple projects. Generally, he found citizens could recall project elements more clearly than other tools, based on recognising streetscape. Compared to other 3D formats, he argued VR allows the citizen to be immersed more closely to the project's context.

Heldal's (2007) study used VR in transportation planning. Experts from municipal councils and citizens were presented VR kiosks to try the experience. During the study, the in-person method allowed questions to be asked after they tried the VR headset. Questions were asked regarding their experience with VR, and opinions and feedback regarding the project. Heldal (2007) found using VR added collaboration between citizens and planners to the participatory process, a similar finding to van Leeuwen et al.'s (2018) study. Heldal's (2007) study implemented graphical changes within the rendering, where the user could change between views and scenes. Including this tool in the VR experience led to better communication and decision-making. During the study, citizens were able to converse with project officials, detailing what they were seeing and elements they thought should be changed. VR was enabling citizens to think more critically of different scenarios, since they the ability to quickly change between scenes and obtain greater context on the project.

Another in-person technique to AR/VR is citizen-designed or co-produced renderings. In this method, citizen feedback is directly applied in the creation of the rendering. Co-produced renderings has citizens look at 2D photographs, plans and any other material, for the purpose of feedback curation, which in turn is used to create the AR/VR rendering. From the literature, one case was found where this technique was applied (van Leeuwen et al., 2018). Van Leeuwen et al.'s study looked at a park in The Hague, Netherlands, to determine how it should be re-designed. It was decided on adopting VR as a visualisation and co-design tool. In this study, three workshop settings were used to garner feedback. The first two sessions were background information workshops, where citizens interacted with researchers and government officials, to obtain information regarding the project. The final meeting, named the co-design workshop, had citizens provide feedback that was then built into a 3D VR rendering. The study found that during the co-design process, citizens were able to reflect and provide instant design alterations. This allowed them to consider proposed changes and their feedback, making the final renderings more in-tuned with their ideas and closer to what the community believed was the best scenario for the project.

Literature has seen issues occur when adopting AR/VR in an in-person participatory process. Heldal (2007) developed a table of identified problems and their proposed solutions. The three main areas of issues are related to the misinterpretation of the visuals. A high amount of misinterpretation was found to be taking place. This happened throughout the project, due to varied knowledge backgrounds of experts and citizens, and general communication difficulties. The aim of VR was questioned by Heldal (2007), building on Al-Kodmany (2002) and Row and Frewer's (2005) comments on technology in participation. Determining where the technology's purpose must be addressed prior to the project taking place, otherwise VR has little to no effect on the process. Additionally, Al-Kodmany (2002) found VR isolated citizens from the participatory workshops setting, where valuable face-to-face interaction and communication was lost.

2.4.2 At-home techniques

The major aspect of at-home AR/VR is accessing the 3D renderings online. This allows citizens access to freely available renderings compatible with an AR/VR device. Similarly to PPGIS, the technology is a mechanism that allows a citizen to interact with data and models in an online setting and at home, meaning it is within the realm of online participation. With the current COVID-19 pandemic, online participation has seen substantial adoption due to social distancing.

Online participation is related to increasing engagement in the decision-making process over the internet, wherein providing an alternative avenue to participate (Evans-Cowley & Hollander, 2010; Kakabadse, Kakabadse, & Kouzmin, 2003; Kingston, 2011; Zheng & Schachter, 2017). Relating to the use of the internet and Information Communication Technologies (ICTs) as tools for participation, are the terms e-participation and e-democracy. Macintosh (2004) defines e-democracy as "the use of ICT to support the democratic decision-making process" (p. 1). From a report published by the Organisation for Economic Cooperation and Development (OECD, 2004), online participation is at the center of e-democracy, where the "introduction of online platforms enable broader participation, participation through a wide range of technologies, provide relevant information in an accessible and understandable format, and engage a wider audience to allow for deeper contributions and debates" (p. 43). However, online participation, like all other participatory methods, has been argued in literature for its nature on participation and citizen-government dynamics.

A reason behind many governments adopting online participation is the belief that a greater audience is reached in the participatory process, de facto more feedback and greater community engagement. Literature shows citizens can be excluded based on a lack of computer literacy, caused by the factors of age, physical capital, and education (Evans-Cowley & Hollander, 2010; Kakabadse et al., 2003; Robbins, Simonsen, & Feldman, 2008; Sieber, Robinson, Johnson, & Corbett, 2016; Zheng & Schachter, 2017). In a U.S. and Canadian context, Kakabadse et al. (2003) argued it is difficult to express an argument online when English is not a first language. This results in individuals excluding themselves from an online forum. Further, social media networks can create a bubble-like participation where groups with certain interests communicate amongst themselves, leading to no meaningful consensus on the topic at hand (Cantador, Cortés-Cediel, & Fernández, 2020; Effing, Van Hillegersberg, & Huibers, 2011; Evans-Cowley & Hollander, 2010; Haro-de-Rosario, Sáez-Martín, & del Carmen Caba-Pérez, 2016; Seltzer & Mahmoudi, 2013). Online participation requires a tricky combination of participatory techniques to work as intended. Evans-Cowley and Hollander (2010) described a hybrid participatory experience of in-person and online, which connects and helps narrow the digital divide generated from web-based participation.

In the online portion of Heldal's (2007) research, it found very few people were able to participate at-home, only ten percent from the original meetings downloaded or viewed the models online. The reasonings behind this lower participation rate was the necessary hardware to run the models and a device to view the VR rendering. Jiang, Maffei, & Masullo (2016) created a web-based VR application trying to counteract the hardware limitations of VR by incorporating a survey into the online rendering. Van Leeuwan et al. (2018, p. 4) built a web-interface for their study that "allowed participants to view the designs on their personal computer, smartphone, or tablet […] and supported remote voting from home". They found citizens who participated at-home had difficulty being confident in their understanding of the project because they lacked a facilitator who could explain the technology and rendering. Al-Kodmany (2002) stated that using VR online makes it possible for citizens to access renderings at-home, benefiting citizens unable to attend the participation location. Due to the lack of at-home participation research in the field of AR/VR, a connection to previous literature is challenging. However, the required hardware to run the technology at home, along with the devices, makes it apparent only a select few in a community would have access. Further, computer literacy and age are important in understanding how to work and use AR/VR technology. With no technician or expert available to the citizens at home, trying to work the devices to their full potential could present certain issues.

AR becomes tricky in defining where it belongs in terms of techniques. Fully functional AR devices, such as HoloLens, tend to be costly and require experts on-site for them to function. However, current smartphones have the hardware capability to project an AR experience. This leads AR to being a mobile technology, as compared to VR, with anyone who owns a smartphone being able to fully participate. Allen et al. (2011) studied citizen's willingness to participate in decision-making if they used AR. They found younger participants had a positive experience with the technology, more so than older generations, mainly caused by familiarity with AR technology and their smartphones. Participants from this study said AR was "a useful tool for visualising proposed designs" (Allen et al., 2011, p. 19). Overall, willingness to participate in planning events increased because they included AR into the process.

Similarly to in-person techniques of AR/VR technology, literature is limited by the amount of cases that involves its use for citizen participation. However, there are patterns that arise from the two techniques. Participants in the studies were found to have better interaction with their surroundings and project proposals, a more thorough understanding of environmental changes, at-home techniques allow citizens to interact in an online format with AR/VR renderings, and there is a better sense of collaboration between citizens and governments when adopting the technology (Heldal, 2007; van Leeuwen et al., 2018). Further, issues arise with adopting this technology in a participatory process. The at-home format has accessibility issues based on its cost and citizen's technological familiarity, and citizens lack a guide or expert to facilitate them in the experience. In-person settings has led citizens to misinterpreting the visuals by isolating them from face-to-face communication during meetings or workshops.

2.4.3 Visualisation tools: From 2D to 3D

Visualisations are important for conveying details regarding spatial context of projects. Lynch's book *The Image of the City* (1960) discussed this imageability of cities and spatial relationships citizens build based on their visual surroundings. Lynch mentioned that citizens connect to their surroundings based on the creation of mental maps, establishing spatial landmarks based on how they view the city. When examining AR/VR technology, it is a virtual experience that tries to simulate a city's transformation, attempting to maintain a citizen's spatial awareness. This connection to a space is important for a citizen to relate the context of a project to the visualisation. When a visualisation is immersive and realistic, a citizen can easily relate to the rendering. In a participatory process, visualisations include photographs of top-down and side views, other key areas to the development, design plans, and with most current projects, photo-realistic or virtual models displaying the final product.

Al-Kodmany (1999) described traditional tools of engagement, 2D sketches and photographs, a failure, mentioning that these techniques have not change to accommodate non-design-oriented citizens. He further argued contextual information about proposed changes lacks any connection to what exists, meaning citizens could not link the project to the visuals. Al-Kodmany (1999) researched different participatory planning processes which used GIS, freehand sketches, and photo-manipulation visualisations. Each had their benefits and drawbacks, but examining computer imaging, the study found it enhanced the decision-making process by "allowing planners to communicate visual relationship and patterns" (p. 43) to citizens. His study is over twenty years-old and the techniques mentioned are now rudimentary. Now, making this connection between conceptualising the project and context is simpler to achieve through photo-real 3D computer graphics. Comparatively, he assesses 2D and 3D formats in papers from 2001 and 2002.

For 3D visualisations, there are physical 3D models which present the project in a natural format, and computerised/digital 3D models shown through a variety of technological means. Physical models allow interactivity with parts of the project that are hard to conceptualise. Computerised and digital 3D models have the same level of conceptualisation, but further allow the citizen to be immersed and "experience a proposed structure or site plan before it is built" (Al-Kodmany, 2002, p. 197). Levy (1995) illustrated a process used in Geneva, New York, using CAD and visualisation software. It showed streetscapes, public spaces, and corridors, and found citizens were more involved with the design process when using VR. Levy wrote that "the ability to visualise a city's form can assist in bringing a greater level of involvement from all participants in the planning process" (p. 357). Al-Kodmany (2002, p. 206) argued 3D visualisations generate greater involvement from citizens because it gives them "unprecedented access to a rich array of data that are presented in an easy-to-understand format". However, he mentioned VR environments lack the hands-on nature that makes participatory workshops so successful. He stated that future projects must incorporate interactivity within the VR experience. Herbert and Chen (2015) researched the usefulness of 3D visualisations, comparatively to 2D, in urban planning. They reiterated a finding from MacEachren and Kraak (2001) that there is a lack of literature which compares the value of 3D geovisualisations to 2D. However, Herbert and Chen found that planners working with complex assessment tasks, 3D visualisations were more useful to their 2D counterparts. Also, 3D visualisations improved the creating of mental images of proposals, and made participants more familiar with the project. Overall, in comparison to 2D formats, 3D visuals better connect the user to the project, its context, and conceptualisation, and can generate greater involvement in the design process, reiterating Al-Kodmany's (1999) argument that 2D formats have been unsuccessful for citizens.

Issues with 3D visuals are apparent, mostly with realism and cost. Cost is a major issue constraining governments, projects, and planners (Al-Kodmany, 2002; Heldal, 2007). When creating 3D computer visualisations, cost related issues are most often associated with software and hardware. To create a 3D visualisation, there is required hardware to run the software and render the models. Further, most software requires a yearly licensing fee which can be costly for individuals. Within the past decade, the price of hardware has decreased yet processing power has increased. The constraint of cost is not nearly the same as it used to be when discussed by Al-Kodmany (2001b, 2002).

There is debate on the topic of realism within visualisations and its importance to 3D's success (Al-Kodmany, 2001a; Billger, Thuvander, & Stahre Wästberg, 2016; Drettakis et al., 2021; Gill & Lange, 2015; Heldal, 2007; Kuliga et al., 2015; Ostermann, 2010). In comparison to 2D visualisations, a common finding is 2D visuals lack realism, giving 3D the benefit and capability of showing accurate details. Lange (2005) mentioned realism is important but is not always necessary to establish common grounds amongst participants. Heldal (2007) found that "complex contextual information (realism) impresses participants and helps them reach a better common understanding of the changes" (p. 147). Gill & Lange (2015) built upon Heldal's argument, mentioning that realism effects the capability of a citizen's understanding on planning issues and policy. Al-Kodmany (2002) found during a community planning process in Pilsen, Chicago, the lack of realism in the 3D visualisation made it difficult for citizens to evaluate how the development would look aesthetically, leading to problems in later stages of the development process. Ostermann (2010) concluded realism is preferable since it gives more information to the viewer, whereas less graphical complexity will be a loss of data. Billger et al.'s (2016) literature review on visualisation challenges expressed a divide on realism. Research voiced a resounding necessity to include realistic elements to virtual environments, while others stated too much realism will make the information too complex and abstract. Drettakis et al. (2021) expressed that the goal of visualisations in urban planning is to present and review project proposals. To fully understand the context of the project, they argued, realism is integral.

While realism is expressed as being important for citizens connecting contextual information of the project to the visualisation, certain drawbacks have been discussed. Most notably, when an image is so realistic, it can mislead people (Al-Kodmany, 2001b, 2002). Obermeyer (1998) argued that 3D visualisations can lead to false conclusions. It is also possible that these 3D renderings can be accepted as the truth due to their realistic nature, as Al-Kodmany (2002, p. 208) stated "there is the danger that audiences may understand a given created image to constitute reality". If a visualisation is realistic to the point it can be considered truthful, then it can be distorted by governments to show a misrepresentation of reality. Stahre Wästberg et. al., (2013) determined too much graphical complexity (realism) could make it difficult for the citizen to understand the visualisation, since abstractions and parameters can be confusing. For planners, Herbert & Chen (2015) found that realism was not always necessary, rather, under certain circumstances, planners preferred more simple and bulky visuals over those that were complex and realistic. While realism might not be integral for planners to understand the visualisation, compared to citizens, they are spatially informed, and design-oriented individuals who can easily connect a visual to the real-world and the project. As said by Al-Kodmany (1999), non-design-oriented citizens are troubled when trying to understand spatial visualisations.

Chapter 3
Methodology

This comparative case study encompasses AR/VR as a participatory tool. Meaning, specific instances of AR or VR counted as one case of the broader study. The comparative case study methodology was implemented due to its ontological, epistemological, and methodological flexibility (Rosenberg & Yates, 2007). Having flexibility in these philosophical knowledges allows for case studies to have distinct temporal and geographic identities without losing uniqueness (Luck, Jackson, & Usher, 2006). In this study, the temporal and geographic characteristics will be different for each case, meaning the case study's philosophical flexibility will not undermine the determining of results. Case studies also "explore, seek understanding, and establish the meaning of experiences from the perspective of those involved" (Harrison, Birks, Franklin, & Mills, 2017, p. 3). This methodological approach is ideal in exploring the nuanced complexities part of the technology's influence on citizen participation. This exploration is perfectly described by Baxter and Jack (2008, p. 138) as they mention case studies "explore in-depth nuances of the phenomenon and the contextual influences on and explanations of that phenomenon". The uniqueness of this research allows for the implementation of a comparative case study to be the preferred methodology, as it is not focusing on one instance of AR or VR, rather an amalgamation of the technology across North America.

3.1 Selection of Cases

The selection process for determining AR/VR to be included in this study followed certain criteria (see Table 1). Instances of AR or VR being used as a civic participatory tool is limiting, which makes finding a suitable number of cases difficult. This resulted in the need to scan beyond a limited geographic boundary, therefore searching in Canada and U.S. The scanning included any projects from French speaking areas due to my bilingualism in English and French. Resulting from the scanning, thirteen projects were found across North America, matching the criteria. From this pool, all thirteen were contacted but only five responded.

Criteria	Include in study	Exclude in study
Implementation of technology	A project that uses AR/VR as a participatory tool. Private developer can be contracted/partnered with the project.	An application/use of AR/VR not affiliated with a government body.
Type of technology	Must be AR or VR. This can include other forms of mixed reality.	Any other form of technology not AR, VR or mixed reality.
Country/language	English and French. Within North America.	Countries that do not fit the language/geographic barrier.
Citizen involvement	Citizens must be the end user of the technology. Citizen feedback is necessary.	Instances where no citizen participation takes place.
Participants	Employees who have worked on or closely with the implementation of the technology.	People who have no connection to its implementation.

Table 1: Summary of criteria applied to determine suitable cases for this study.

3.2 Interviews

For data collection, semi-structured interviews were completed with representatives from each of the five cases. In total, six interviews were conducted with a total of nine participants (see Appendix III). Using semi-structured interviews allows for rich, powerful, and comparable qualitative data (Bernard, 2017). Within citizen participation academia, when collecting qualitative data from policy makers, city officials, or government workers, semi-structured interviews are often the most profound and reliable method (Alawadhi et al., 2012; Boehner & DiSalvo, 2016; Sangiambut & Sieber, 2016; Schroeter, 2012). Since this comparative case study focuses on the implementation of AR/VR in participatory processes, semi-structured interviews were the clear method of choice. One of the important strengths of interviewing, as mentioned by Dunn (2016, p. 150) is its capability of "gaining access to information about events, opinions and experiences". These participants have unique experiences in working with AR or VR, and have opinions on the feasibility, workability, viability, and future of the technology.

While telephone or video interviews are nuanced compared to in-person (Shuy, 2003), the implementation of AR and VR as case studies are limited, as shown by the final sample size. This caused my search to look elsewhere than near the University of Waterloo. Additionally, this study was completed during the COVID-19 pandemic which has forced most people to work remotely. Shuy (2003, p. 177) lists the criteria in deciding between telephone and in-person interviews, with one being "economic, time, and location constraints of the project". Having to travel for in-person interviews across North America during a pandemic, is not cost efficient or safe, therefore, it was decided semi-structured video interviews would be the main source of data collection. Participants were asked questions (see Appendix II) related to the project, their position and work on the project, the purpose/goal of using AR/VR, how citizens interacted with the technology, the benefits and challenges they have witnessed with the technology, how feedback was obtained, the technology's future, etc. While there were structured questions, follow-up questions were asked. Sangiambut and Sieber (2016) raise an issue of biased responses from interviews. The answer to questions could be a false truth when government officials are presented with questions related to improving citizen participation through government applications, respondents might force themselves to answer as "pro-citizen engagement" (p. 146). In creating this study's questions and any follow-up, open-ended questions were used to limit biased responses.

The interviews followed an opportunistic sampling method due to its flexibility, particularly in a political setting where projects can change quickly and without notice. To aid in finding potential interviews, a snowball sampling method was applied. This allowed participants to inform colleagues or other projects, advising me of not previously known cases, and resulting in an increased number of interviews. Using the snowball sampling method discovered one case.

3.3 Data Analysis

The interviews resulted in multiple transcripts. The best method to extract the necessary data and information is to use coding techniques. A descriptive coding technique was applied, along with deductive logic since this study is building upon existing theory. ATLAS.ti is one of the many computer assisted qualitative data analysis software (CAQDAS). This software allowed for a clear understanding of the data, a database to easily code the transcripts, and made the analysis more thorough. ATLAS.ti added rigour to the research process, something which is difficult in other stages of this study. Further, it benefits the difficult process of linking data to the gap in literature (Beekhuyzen et al., 2010). Due to the benefits of using computer assisted software, ATLAS.ti was used as a tool to organise the data, so that themes were more apparent from the interviews, to add rigour, and aid the thorough analysis of data.

An important component of the data-gathering process is reaching saturation. It is defined by Hay (2016, p. 454) as "the point in the data-gathering process when no new information or insights are being generated". Reaching this point of saturation with interviews is not immediate and can require many. Having a total of six interviews with nine respondents is a clear limitation to this study. To reduce this limitation, a strong coding technique, analysis of the transcripts and results was applied to reach the point where no new information was found.

3.4 Description of Cases

	Boise 11th Street	**New Rochelle Virtual Reality**	**Lethbridge ELUS and SASP**	**Seattle HoloLens**	**Reimagine Robinson Street**
Location	Boise, Idaho	New Rochelle, New York	Lethbridge, Alberta	Seattle, Washington	Orlando, Florida
Year	2019	2017-Present	2015-2016	2017	2019
Example of	Transportation planning	Urban redevelopment, transportation planning	Land use, redevelopment, transportation planning	Affordable housing, zoning, bylaws	Transportation planning
Government	City of Boise, Ada County Highway District, Idaho Transportation Department	City of New Rochelle, Department of Development and Planning	City of Lethbridge	City of Seattle, Department of Neighbourhoods	City of Orlando, Florida Department of Transportation
Technology	VR	VR	VR	AR, mixed reality	VR
Developer	Kittleson & Associates	Crafted Creative	Stantec Consulting	Zengalt Inc.	Kittleson & Associates
Content of rendering	Bike lane, green space, reducing lanes	Redevelopment of downtown core, major road changes, multiple scenarios	Redevelopment and land use planning, multiple scenarios	Zoning bylaws, building redevelopment, affordable housing, multiple scenarios	Bike lane, green space, reducing lanes

Table 2: Summary of project characteristics of the five cases researched in this study.

3.4.1 Boise 11th Street

The previous 11th Street in Boise, Idaho was a two-lane, two-way street. The proposal was to reduce lanes by including a protected and striped bike lane. The type of project was named a road diet, which in transportation planning is meant to reduce lanes. VR was used during an engagement session that was brought on-site to a nearby park, unique to this case, and run by the consulting company Kittleson & Associates, in partnership with the City of Boise. During this engagement session, citizens viewed a 360˚ rendering of the street with different scenarios to choose from. Feedback was obtained through questionnaires provided to citizens after viewing the VR. Questions asked were related to the rendering, proposal, scenarios, and general opinions on the project.

Figure 1: One of the views in the 360˚ environment showing the redesigned street in Boise, Idaho. This rendering was used in a VR device.

Bringing VR on-site made this case unique in comparison to the others. It was made possible by using smartphones instead of large mobile kiosk versions of VR which require more money and resources to set-up outside. As immersive as VR is, having this engagement session where the project was taking place added an interesting perspective on how accurately the rendering represented reality and its effects on citizens. VR was supplemented on-site by photographs, maps, and other visuals of the current and proposed reconstruction of the street. Similar to other cases in this study, VR was not a standalone participation method, rather it required other techniques.

Figure 2: A citizen trying the VR headset during the on-site participation meeting for Boise 11th street project.

3.4.2 New Rochelle Virtual Reality

Also known as NRVR, the project of New Rochelle Virtual Reality is the largest in this study in terms of resources, budget, and proposals. It focuses on transportation planning and redevelopment of the downtown core. The project began as part of the Bloomberg Mayor's Challenge, which saw cities across North America pitching their ideas to obtain funding. NRVR was a finalist city that obtained a million-dollar award over a three-year contract with Bloomberg Philanthropies. Furthermore, in 2018, the project received a grant incentive program from the State of New York for ten million dollars. The project is complex, laid out in multiple stages, and is still ongoing. Further, the COVID-19 pandemic complicated the project as it was meant to officially launch in 2020 but was delayed significantly.

Currently, the project is focusing on one major proposal, the LINC. This is a revitalisation of an old highway which passes through the downtown core of the city. Using VR, the rendering shows the major change going from a raised highway to a bike oriented, pedestrian friendly area, and the incorporation of park space. This is supplemented online through a well-designed platform with visualisations and scenarios for residents to view without requiring VR devices. Their feedback production is online surveys for citizens to fill-out. VR kiosks have been used in the New Rochelle train station to inform citizens of the proposal and to receive on-site feedback, but due to COVID-19, its use is limited to appointment only. For NRVR, feedback has two purposes. First, it is used in creating the renderings and scenarios shown through VR. This is a process of co-producing renderings, where citizen feedback is directly made into a rendering. Second, once the co-produced renderings have been viewed, feedback is again collected and is used to either create new renderings or accompany the existing ones to aid in the final decision.

Figure 3: The rendering of the LINC project, one of the many projects of NVRV using virtual reality.

NRVR differentiates itself from other projects in this study as it is meant to be a framework for future development proposals. The goal is to have an operational framework for future developers and city projects in New Rochelle to use VR as an engagement, visualisation, and participatory tool. One of the requirements from the Bloomberg Philanthropies contract is to create this framework so other cities can adopt and modify their work. This is defined as an open-source framework which allows other municipalities the ease of adoption VR technology.

3.4.3 Lethbridge ELUS and SASP

The projects in Lethbridge are two separate uses of VR: the Southeast Area Structure Plan (SASP) and the Efficient Land Use Strategy (ELUS). The SASP was a fly-through rendering using VR goggles and a projector during the participation session. The purpose was to provide a visualisation for the long-term development of the Southeast area of Lethbridge. The rendering showed before and after visualisations of certain road intersections, land parcels, and what would be built in the future of the currently unbuilt area. The ELUS was a conceptual plan which had multiple different scenarios for how the future of the city could develop based on existing growth and density alterations. It was used as a visualisation to help citizens conceptually visualise the possible changes.

Figure 4: Scenario C of the ELUS project. This rendering was shown as a video in the VR devices.

The two projects were used to garner feedback on multiple different issues and topics regarding the proposals. The ELUS included online surveys as part of their participation process. Feedback was collected in-person during both project's presentations. Smartphones were used in replacement of typical VR devices and were placed in Google Cardboards. The flythrough renderings were uploaded on YouTube in a 360˚ format so people at home could view them with or without VR instruments. Each project's visualisations were video formats which created a guided visualisation of what the citizen is supposed to see. The ELUS and SASP renderings were developed by Stantec Consulting.

3.4.4 Seattle HoloLens

Using the proprietary devices made by Microsoft, the Department of Neighbourhoods at the City of Seattle applied HoloLens to their engagement process at open houses. These events were held as part of the Housing Affordability and Livability (HALA) program, where HoloLens showed scenarios of zoning and urban planning concepts to citizens. These scenarios were built by the start-up company Zengalt Inc., using existing SketchUp models made by the city and incorporated them into the visualisation. This is the only case part of this study which uses a form of AR and mixed reality.

Before this project, the Department would walk the neighbourhood as part of the engagement process, to discuss the issues and concerns of residents. Due to the scale and magnitude of the HALA, which oversaw many areas of the city, the time frame was not feasible to include a walk-around. It was decided HoloLens would be adopted to perceive a walk-around virtually and still have realistic aspects citizens could connect the project to their neighbourhood. The scenarios shown depicted new buildings, zoning changes, and bylaws that are difficult to understand on paper without visuals, such as setbacks and height limits. Residents were able to switch between scenarios with voice commands, making it user guided. Feedback was conversational, the staff talked to residents after using the HoloLens to get a sense of what was liked and disliked, and how they viewed the proposals.

3.4.5 Reimagine Robinson Street

Figure 5: The second VR scenario showing a proposed intersection with the shared bike lane and pedestrian walkway from the Reimagine Robinson Street project.

Robinson Street is a major corridor in the City of Orlando. Similar to the 11th Street in Boise, it was a redesign of the street focusing on reducing lanes and adding a bike path. The project's goal was to make this corridor more user-friendly by adding a shared path for cyclists and pedestrians. To visualise the major changes, the City of Orlando along with the Florida Department of Transportation (FDOT), hired

Kittleson & Associates to build 3D renderings of different areas along the corridor. These renderings were viewable at open houses as part of the public meeting process, where it was accompanied by other 2D visuals. The project used an interesting combination of Google's travel time and VR to inform citizens of how this proposed reduction of lanes would affect traffic flow. The renderings were put online for viewing under the FDOT's project page, but feedback surveys were only available to those who attended.

The project used the website IrisVR to host the renderings. It was chosen because of its simplicity in downloading the rendering on a personal smartphone during an open house and simply place it into a Google Cardboard. The project was similar to 11th Street Redesign in Boise since it was developed by the same consulting company. It falls in-line with most cases in this study which opted to use smartphones as peripherals during their participation process, due to their cost-benefit. The alternative VR systems are more expensive and fully equipped, such as the Oculus and HTC Vive.

Figure 6: A citizen trying the VR headset during a participatory meeting at the Reimagine Robinson Street project.

Chapter 4
Results

This section will present the interview results. In relation to the research question, responses had two main findings: benefits and challenges of participatory AR/VR. Responses indicated that AR/VR can be integral for disseminating urban planning information and concepts, but has difficulty being used as a participatory tool. Each result will be presented as a subsection in this chapter, following a similar layout. The overarching topic will be introduced and subsequently discussed through related subtopics and subthemes found from the respondents. Direct quotations from interviewees will accompany the findings. By using the comparative case study methodology, the five cases from this study will be compared in each section to emphasise their commonalities and differences.

4.1 Benefits

Interviews found several benefits when it comes to implementing AR/VR. Respondents were asked about the existing and potential benefits of adopting AR/VR as a participatory tool. This discussion determined four categories: citizen, government, technical, and participatory (see Figure 7). These categories are broken into subthemes which relate to the benefit. *Other benefits* will be the final section, where benefits outside of the main categories were found and have occurred in one single case.

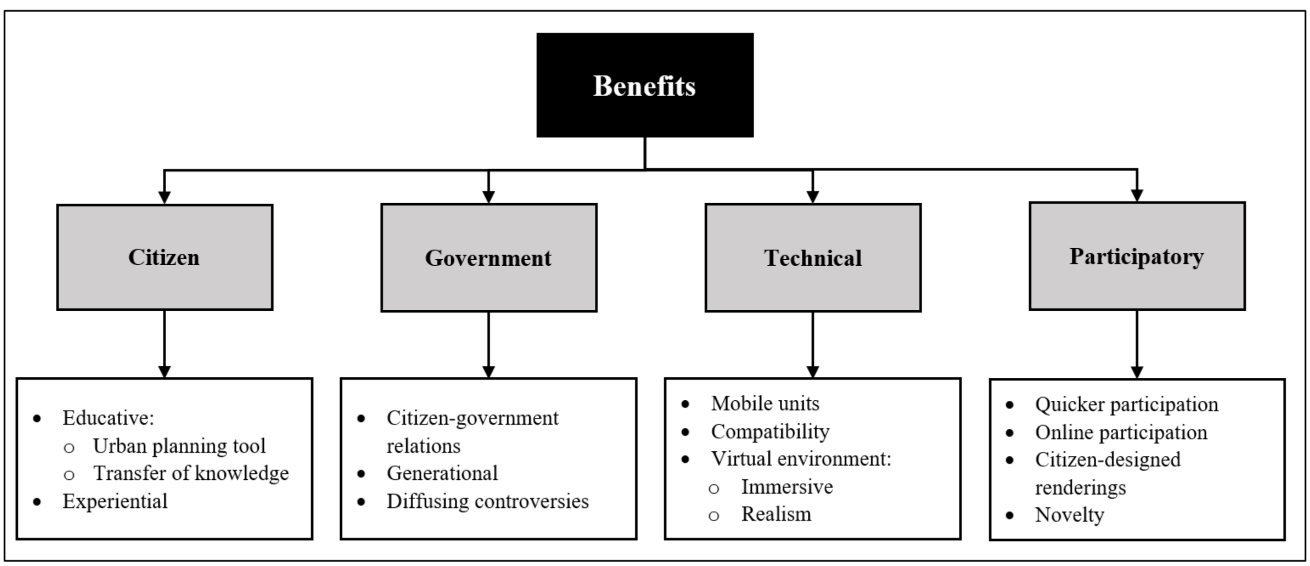

Figure 7: Benefits of participatory AR/VR.

4.1.1 Citizen Benefits

Citizen benefits relate to how the technology and its adoption are advantageous for the citizen. These benefits are classified into two categories: educative and experiential. The educative finding discusses AR/VR as an urban planning tool that allows citizens to understand complex planning terminology and issues. The experiential finding relates to the experience citizens have when using the technology.

4.1.1.1 Educative

AR/VR technology benefits citizens by educating, disseminating, and explaining complex urban planning issues and topics in an easy-to-understand visualisation. The responses indicated that the educative experience citizens have after using AR/VR allows them to better comprehend planning language and terminology, and visualise the context behind the project. The main benefit of AR/VR being educative is its purpose as an urban planning tool.

Participants from the five cases commented on the complex nature of urban planning and how this complexity causes citizens to struggle in determining the best scenario for the project. This issue of complexity deals with the experts and non-experts in urban planning. It was made clear from respondents that AR/VR is a valuable urban planning tool which effectively disseminates complex planning information to any citizen. The respondents (D and E) from the *Lethbridge ELUS and SASP* noted that their VR visualisation was meant to be a participatory tool and educative for. This is a common result amongst all cases, that their adoption of the technology always included an educative element through visualising the project:

> "It was another tool for us to use to help people better visualise and understand what these policies actually mean." Respondent D.

Respondents from the *Seattle HoloLens* case discussed their use of the AR technology HoloLens. It was an interactive tool capable of showing zoning bylaw change. In this case, citizens were given different scenarios of bylaws. The project's intention was to visualise amendments to the bylaws so affordable housing could be built. For some citizens, these changes were difficult to understand on paper, but once wearing the headset, understood how their neighbourhood would change after changing the height and setback levels. This finding relates to understanding the context of a project through visualising the changes, as described by Respondent H:

> "One person in the meeting was like 'I thought I cared about the height, I don't, I care about the setback now. That's way too close to the road or that's not close at all'. After using the HoloLens, they understood some of the complex issues we were trying to talk about."

Respondent G from *Seattle HoloLens* explained AR has the capability of explaining complex conversations of our abstract world: "[W]hen we have these civic conversations about policy and programs, it's always abstracted from that three-dimensional world we live in. It's either in written form or at best a photo realistic picture but even that is hard to place yourself in, so I think it can be helpful [when using AR] in engaging with the built environment". Respondent G argued that AR allows a citizen to understand real-world complexities, whereas photographs or paper plans are difficult for people to visualise.

The 3D nature of AR/VR allows citizens to grasp complex plans and use the technology as a tool for communication. The case of *Boise 11th Street* restructured a two-lane road into one-lane. Certain aspects of this proposal used intricate CAD drawings and photographs. They understood that giving citizens plans in a 2D format, with top-down and side structural views, is not the best approach to make citizens comprehend the project:

> "If you supply 2D CAD plans with terminologies, you know that's not straightforward with a lot of people. People can better connect with VR renderings. I would say that its communication right off the bat of what it's going to look like and it's easier to understand. It gives them [the citizen] background information on the project." Respondent A.

This case found citizens grasped a greater understanding of the project, since the VR renderings simplified complex aspects. Citizens were able to connect what they were seeing in the rendering to the project, making VR an effective tool in communicating the project.

A transferring of knowledge occurs when adopting AR/VR as a visualisation. There are two structures to this finding. First, the transferring of knowledge takes place at the decision-making level, where the decision-makers are presented with a tool that produces new knowledge to make decisions. Second, there is a transfer from visualisation to citizen, meaning citizens gain information from an easy-to-understand visualisation. The geographies of the cases make it interesting in how respondents expressed these structures. Respondent D and E from Lethbridge, Alberta mentioned that the VR renderings were not allowed during public meetings, therefore, decision-makers had to inform themselves on the project. They expressed that the technology had capacity in educating citizens, but constrained decision-making because on their planning process. Respondent B from Boise, Idaho voiced decision-makers "harbor their own biases and opinions, […], they need more professional information, like experiencing it, to make a decision". Respondent B further expressed decision-makers as citizens with a slightly greater professional knowledge, but still require visualisations to make the decision that is beneficial to everyone. The remaining respondents highlighted that AR/VR can aid decision-making. This is possible by providing the decision-makers a unique tool which increases their understanding of spatial proposals. Further, AR/VR addresses the project, planning policies, and spatial phenomenon in a simple and understandable manner, providing citizens a tool that enhances their knowledge, which informs them in the planning process. Respondent A summarised the value of AR/VR in disseminating information:

> "Engineers and planners can understand the project with 2D plan views and drawings, but the general public still doesn't. They need to actually see it, experience and feel it. That is was VR has the potential to do."

Lastly, respondents found the role of a planner and their position in decision-making, project proposals, plans, and participation processes, is confusing to younger and less active citizens. AR/VR can address the field of urban planning and the concept of planners, by providing a fun and interactive alternative to viewing complex plans, making it interesting and immersive. For younger people, Respondent C mentioned that most are unaware of urban planning:

> "I've worked for this municipality [New Rochelle] for years and I'm a planner but if most people ask me what I do, they ask 'what does that mean?' This way [using VR] you can actually show them what types of things can happen in the planning process and get them interested." Respondent C.

4.1.1.2 Experiential

The experiential finding involves the experience citizens had with using AR/VR. Each citizen has a unique way of understanding information given to them. For some, it is hard to contextualise the project and its future if they are given photographs or plan views. It is more difficult for people to understand context without an accurate and realistic visualisation. Respondents found trying an AR/VR device made it easier for certain citizens to understand the project. Respondent B from *Boise 11th Street* said:

> "You can talk through things all you want. You can throw facts at people, and it doesn't mean anything unless they can see it. The better they can see it and experience it with VR, the more they can understand it and produce informed opinions."

The experience of using AR/VR was found to be sensory for many of the citizens. At times, it was a visceral feeling to be viewing a realistic rendering showing how the project might affect them. From *Seattle HoloLens*, citizens cried at meetings after wearing the devices. Further, respondents (Respondents F and H) mentioned that citizens had an enjoyable experience with the technology, something they rarely saw with any other tool used in citizen participation. Respondent H talked about human nature and experiencing something new. They brought this into the conversation about AR, its novelty and the user's enjoyable experience:

> "People love new experiences, and they want, they need to have that feeling in their body. If they are not able to be on third avenue [the site of the project], to see the building is this tall, how do we make an experience where they get to have that? AR is the experience that makes it happen." Respondent H.

4.1.2 Government Benefits

Government benefits relate to how the technology effects governments. This benefit is observed through citizen-government relationships and the generational factor when implementing AR/VR. Further, the respondents discussed AR/VR's benefit in diffusing controversies surrounding government projects, by giving governments a tool that realistically and accurately shows what is being proposed, and can be used proactively in disseminating information early in the planning process.

4.1.2.1 Citizen-government relationships

A citizen's relationship with their government is important in trusting their ability to make the correct choices. What bolsters this relationship is adopting AR/VR, which is a novel participation technique. This technology is new to many people. To citizens, they see this technology as a government trying to improve upon existing conditions. This progresses trust, the willingness to try new techniques, and a general benefit to questionable relationships.

Trust in a citizen-government relationship is important. This relationship can be unstable and untrustworthy, caused by years of miscommunication and wrongful action. While this was not an issue in any of the cases, respondents discussed how implementing this novel and fun technology to the decision-making process shows a willingness by the government to improve on vulnerable areas. Respondent G from *Seattle HoloLens* mentioned that "honestly, a benefit of AR is the willingness to try something new on the part of the city to help its citizens in decision-making". This willingness is described by Respondent C as trust in the citizen-government relationship:

> "Using VR shows a trust factor. The city's being more open to trying new things to engage more people. So, it creates this trustworthy synergy between the citizens of the municipality and the administration."

4.1.2.2 Generational

Respondents discussed the generational trait of AR/VR, referring to the intrigue trying the technology for the first time. Younger people, in comparison to older generations, are most likely to have used the technology before or understand what the technology offers. Respondents D, E, and H described younger people as understanding through prior experience with video games and graphic design. Whereas, for older generations, this technology is new and an unknown, but still carries intrigue. This is discussed by Respondent D, describing AR/VR as "more generational, where older people are less likely to know anything about it". In terms of government benefits, it attracts young and old people, causing it to be useful in bringing all people into government processes. Incorporating younger people into civic governance and processes is a challenge, but AR/VR is commonplace amongst many people in this generation and has certain technological attraction they are intrigued by. Getting younger citizens involved early leads to greater and more diverse participation for the future. To understand the younger generations interest in technology, Respondent H mentioned their son:

> "Young people are playing immersive games on their devices that are so sophisticated, they are around this stuff [virtual technology] all the time. My son is into gaming, and he explains all of these things to me and he's really passionate about it. It seems like a lot of cool conversations could happen if we can use the technology to bring more young people to meetings."

Since governments want to bring a more diverse range of people into civic processes, there is potential in AR/VR to make this a reality. This is mentioned by a respondent from the *Lethbridge ELUS and SASP*:

> "One thing I can see is how it [AR/VR] can be used in our planning process is for younger people. Exposing the youngsters to some of this stuff [government process] can really be interesting in getting younger people involved." Respondent E.

As for older generations, while the technology can be an unknown, the cases found that citizens were still excited to try it. The technology was not unfair to a certain age group, rather the citizens found it a fun and different to how they usually participate. From the cases, AR/VR was never a standalone participatory technique, rather it was used alongside others. This helped some older citizens who struggled understanding the technology, to connect the virtual environment with what was familiar to them in a civic process. For the case of *Seattle HoloLens,* it brought joy to citizens who used the AR devices, which was surprising to the respondents:

> "I think because of who is drawn to coming to events, people who were in the older set, it brought a lot of joy to senior's faces, which I didn't expect." Respondent F.

AR/VR technologies are understood, commonplace, and intriguing to younger generations. It has potential to incorporate younger people into citizen participation, something that has challenged participatory processes for decades. Older generations are just as intrigued and enthusiastic with the technology, finding that it can be incorporated into a process they are familiar with.

4.1.2.3 Diffusing Controversies

AR/VR is proficient in diffusing controversies. Controversies are nothing new to projects, their proposals, and plans. Sometimes arguments arise for how they change the neighbourhood, the price tag, how it might affect the future of the area, NIMBY, and if the project is required. These disputes are an identifiable characteristic of citizen participation and AR/VR aids in addressing many of them, which is a proactive approach in tackling issues early in the process.

For citizens in the cases, using the virtual technology dispelled certain project controversies by providing factual and correct information through visuals. Generally, in municipal settings, citizens talk amongst themselves on what they like and dislike regarding proposals. From *Seattle HoloLens,* respondent G and H described citizens attended the meetings with predetermined ideas of the project, mainly negative, however, the AR visualisation shifted their understanding. In one instance, a citizen attended the meeting because neighbours brought up a controversy regarding the height alterations. After viewing the renderings, the citizen cared more the setbacks than the heights: "I remember one person being like 'I thought I cared about the height, I don't, I care about the setback now" (Respondent H). Further, it was found that some citizen's understanding of the project evolved from miss-information being transferred around the neighbourhood before the first meeting took place. Once in the AR experience, many were dispelled:

> "All of the things they [the citizens] were hearing from their neighbours, which were negative, for some folks they were dispelled, and it turned them into myths. It was like, 'oh okay, I have a better feeling of this environment and the changes'." Respondent H.

Using an AR/VR device allows the government to reveal different scenarios of the project, which aids in demystifying each characteristic. With citizens, there is a fear of the unknown. What will this project do to our neighbourhood? How does it affect our livelihoods? What exactly is this project proposing? Participatory meetings can find it difficult to answer questions shadowed by fear. The cases demonstrated AR/VR benefits projects by making everything more known and accepted (Respondent C, D, and I). For certain cases, the goal of adopting AR/VR was to diffuse fear surrounding the unknown by distributing information through a visualisation. This is not to say the purpose it to make every member of the community on-board with the project, rather to allow everyone an equal understanding of what the project is offering. Through disseminating information, AR/VR can spur earlier conversations and discussions, being proactive regarding the project by showing all possibilities and scenarios before any work takes place:

> "There is a lot of resistance to projects. Citizens get this fear of the unknown. This [VR] kind of helps it being more known, so there's a little bit less fear around it. Somebody can still be opposed to something but at least they know more about it [the project] in the end." Respondent D.

4.1.3 Technical Benefits

Technical benefits deal with the characteristics of developing and adopting the technology. The technical benefits identified by respondents have been classified into different themes: mobile units, compatibility, and immersive and realism.

4.1.3.1 Mobile Units

AR/VR allows the planners, stakeholders, citizens, and everyone from the planning and participatory process, an immersive experience on the site of the project. This generates a specific and interesting experience for the user: they can easily connect what their viewing virtually to the real-world. Citizens generate a much better understanding of what is being proposed and can see these changes real-time when taking the device on and off. *Boise 11th Street* was the only case that adopted the technique of bringing AR/VR outside and on-site of the project. This case used phones in a VR holder (similar to Google Cardboard) with viewable renderings in a 360˚ environment. These devices were "brought to a park that resides alongside the road and had a booth set up for anyone who wanted to see the rendering" (Respondent B). Citizens connected what they saw virtually in the VR environment to the real-world, since they were on-site of the project.

Another finding from mobile units is the ease of working in any space. With smartphones capable of viewing AR/VR, most citizens own one. Smartphone users are in tune with their devices, which limits technological challenges and allows the meeting to be placed in a variety of locations. If smartphones are used, AR/VR can be set-up and operated with relatively few conditions: a smartphone, hosting service for the rendering, and a VR holder. Due to the technology's ability to work in different spaces, *NRVR* and *Lethbridge ELUS and SASP* were able to set up VR booths in areas of high traffic.

NRVR made multiple VR kiosk that were transportable and used high-end devices which included interactive hand-held remotes. Multiple units were placed in the New Rochelle train station. This location was chosen due to the high volume of citizens who pass through the area. This location and method of participation was made possible by the technology's characteristic of being a mobile technology. At the time of the interview, COVID-19 had forced them to setup the kiosks by appointment only:

> "Our plan was to have anyone try the VR, but with COVID, at the moment it is appointment only. Our vision is to have it [the kiosks] more staffed on weekends and evenings, not so much in the middle of the day when there's less traffic at the train station. During off-peak times, we would invite neighborhood groups, school groups, to come in and use the kiosk." Respondent C.

Lethbridge ELUS and SASP used old smartphones from employees to pre-download the videos, application, and anything required to properly run the VR rendering. Since smartphones were used, Respondent D and E had a booth at Lethbridge's home and garden show, another high traffic area. Citizens were able to pass by, view the project in VR which was accompanied by other visuals (photos and a projected video of the site), and provide feedback.

4.1.3.2 Compatibility

The technology's compatibility is the 3D space that planners, engineers, and certain government employees work in. Lots of spatial data, especially renderings, buildings, city density, GIS feature and surface data, incorporate a 3D element. This 3D element is compatible from data to AR/VR rendering. 3D data can be cross-platform, with Computer Assisted Design (CAD) files being brought into a GIS space with ESRI products, and from there, an AR/VR rendering can be made. Similarly, SketchUp files are compatible with 3D design software. However, proprietary file types and software sometimes constrain the import/export capabilities of the renderings.

From a government standpoint, what makes compatibility beneficial is being able to use their existing data in a virtual rendering. It gives governments the opportunity to create the rendering in-house, without requiring a third-party. If in-house is not possible, this was the situation for each case, then the third-party developer can reuse what already exists, leading to a less expensive final product.

Seattle HoloLens were able to reduce cost and time by reusing existing models from previous projects. For *Boise 11th Street*, there was already an existing arsenal of 3D models and data built over time which was reused. In the end, making it quicker and easier to create the renderings:

> "To create a VR or AR experience, it's not a lot of effort depending on what tools you use because the 3D network and modeling you've done, that's all being reused. That's actually what a lot of people don't realise." Respondent A.

Another benefit of compatibility is in using game engines to create the virtual environment. While none of the cases utilised game engines to create the visualisations, *Seattle HoloLens*, *Boise 11th Street*, *Lethbridge ELUS and SASP,* and *Reimagine Robinson Street* discussed how impactful this tool will be for the future of the technology. Respondents understood how effective a virtual environment in a game engine can be for adding realism and ease to the creation process. Respondent H described game engines in urban planning as "being able to import 3D models into a pre-built world for you that is ready to take on what you give it". Further, game engines have built-in AR/VR functionality, and capable of creating scenes, renderings and fully immersive environments users can experience, interact, and move in. They include existing models, textures and construction capacities which make them easier than current alternatives in urban planning (Autodesk and ESRI). The engine's compatibility is import existing models and data. For example, Unreal Engine, one of the leading game engines developed by Epic Games, allows a wide variety of 3D file types, including Autodesk's proprietary .dwg files. ESRI's CityEngine VR Experience uses Unreal Engine to transform GIS and 3D data into a VR experience. Respondent A talked about the ease of file transferability and project replication in adopting game engines:

> "Some of our current tools they're very specific. For example, the architectural industry offers a lot of architectural 3D models that are proprietary to their software. With game engines, you can bring in those proprietary 3D models and any other content. It can then be replicated for any project."

Finally, Respondent I from *Reimagine Robinson Street* described compatibility of 3D models in different fields. With a background in architecture, the respondent witnessed the compatible nature of AR/VR in creating the virtual environment. They described working with 3D models as easier than sketches, since the creator can alter, fix or touch-up the models at any time. They explained models do not need to be recreated from scratch, rather existing models can be altered to fit the requirement, which results in saving time and money:

> "A lot of times, when you're drawing in AutoCAD, that drawing can be easily made into a 3D model, which is kind of 360˚ environment. You don't have to go back to drawing board and recreate something within your default creation process. It's just a matter of exporting it in a different format and at that point it becomes much less expensive." Respondent I.

4.1.3.3 Virtual Environment: Realism and immersion

Findings from the interviews identified two benefits that relate to the virtual environment of AR/VR technology. These characteristics are the feeling of immersion in the virtual environment and its realism.

A defining characteristic of AR/VR is its immersive nature. A user is virtually placed in a realistic rendering that can be interactive and an enhancement of reality. Trying to visualise urban change through 2D pictures and photographs makes it difficult to fully embrace and conceptualise what is being changed and how it affects the surrounding area. The immersion of AR/VR visualises and senses the immediate change to a real-world space. Of the five cases, all mentioned the immersive and realistic nature of AR/VR. *Seattle HoloLens* was the sole case to discuss how immersion affects the user's senses, making them emotional towards the visualisation.

Immersion allows citizens to conceptualise the project by placing them into the virtual world, which relates to the educative experience of AR/VR. Looking more directly at the technical side to this benefit, immersion allows citizens to feel as if they are placed on the project's site, visualising the finished product, and connecting it to what exists. A similar discussion was brought up by Respondent A when talking about the benefits of the technology:

> "One of the first benefits [of VR] is putting a person that's interested in the project on the ground themselves virtually and the rendering is the finished project."

Similarly, respondents from the *Lethbridge ELUS and SASP* discussed how VR immersion works. Citizens feel connected to the rendering because there is recognisable buildings and streetscape. The *ELUS* project was entirely conceptual regarding a change in density of an area in Lethbridge. The rendering visualised how amendments to the bylaws would affect the neighbourhood:

> "You can fly through the street, see the streetscape, see things you know and recognizing buildings and build forms. You get a better feel and connection to what you're seeing, and this all goes back to having a better understanding of the project." Respondent E.

Another finding of immersion is seeing the full extent of the area being change. In the case of *Reimagine Robinson Street* and *Boise 11th Street*, respondents mentioned the importance of the 360˚ environment. Respondent I compared AR/VR to photographs and plan views. The typical photographs of participatory meetings show restrictive extents of the project from top, front, and side views, whereas being in AR/VR rendering, the user is immersed into viewing their entire surrounding:

> "With VR, what I realized was that you had an opportunity to put the person in the environment and have them experience what it would look like in 360˚. It gave some added benefit to show things that are beyond your immediate frame compared to what photos and other planning/architectural pictures do." Respondent I.

Originally, *Seattle HoloLens'* participatory process was a neighbourhood walk-around. In this scenario, city officials would walk and discuss the project with their residents. However, time constraints and the enormity of the project limited this scenario. *Seattle HoloLens* was able to recreate this walk-around through an immersive AR experience. Compared to past walk-arounds, citizens felt more immersed and understanding of the proposed changes. The virtual walk-around produced a unique finding, citizens became so immersed into the realism of the changes, it generated emotions and feelings towards the proposal. Respondent F said certain citizens started to cry while in the AR environment. The citizens could feel themselves in that space and see the change, as if it "feels like this could be my neighbourhood". Respondent H mentioned that certain citizens produced audible gasps, surprised with the immersion and what they were experiencing. The respondent said "not only were there tears, but also a handful of folks who were surprised. They didn't know the technology and when putting it on, they were like ‘oh’”. Further, respondent H discussed how the proposal was personal to many residents, with AR making them sense the changes:

> “In the rendering, they could walk down the street and feel what its like if their house is closer [talking about setbacks], how tall is four stories next to their house, so it really helped them have a sense in their body of what those changes would mean.”

While immersion is a unique part of AR/VR, realism is integral to the how easily a user can become immersed and connected to their virtual surroundings. Realism makes it possible for the citizen to understand their environment. Respondent H described the importance of realism as “every realistic cue in your [virtual] environment grounds you to make sure things are right”. If there were unrealistic aspects of the virtual environment, it disconnected the user from the virtual space and made them less inclined to understand the visualisation. Since AR/VR showcases a detailed and realistic virtual environment, the benefit identified by respondents is that realism allows citizens to conceptualise the project and connect it to the real-world. *Lethbridge ELUS and SASP* built a 3D rendering to show how a complex change could affect the neighbourhood. It was built with an understanding that it is important to familiarise citizens with the environment, so that a connection between the real-world and virtual environment can be made.

Finally, AR/VR’s realism is benefited by accuracies of 3D models. 3D models have already been identified as beneficial towards compatibility, but they also make the rendering realistic. Standard 3D models in SketchUp or AutoCAD are built by scale, using precise measurements. Once placed into an AR/VR rendering, their dimensions are accurate to the real-world. The accuracy of the 3D models generates a level of immersion, and the precision shows a truth in the rendering:

> “The source file in SketchUp was accurate to the inch and was realistic for anyone who wanted to try the HoloLens.” Respondent G.

Furthermore, Respondent A from *Boise 11th street* discussed VR’s truth to reality, resulting from geometric accuracies. When building the rendering, it must be understood that there could be confusion caused by the visualisation. It must be genuine and have truthful elements, which is discussed by Respondent A:

> "We have to be aware of the truth in virtual reality. If we ever are hit with that question, then we have to be able to defend it [the rendering]. I think with the CAD files and their accuracies, it would reinforce it."

4.1.4 Participatory Benefits

Participatory benefits are aspects of the participatory process which benefit from using AR/VR. These benefits include the effects on participation, the possibility of online and at-home participation, citizen co-produced renderings, and the technology's novelty.

4.1.4.1 Changes in Participation and Feedback

It was found that AR/VR had a minor benefit on participation and feedback. Respondents found it difficult to describe feedback differences between AR/VR and the traditional formats of visualisations. However, some respondents still found AR/VR slightly changed participation. They found that the technology made the feedback process quicker since the citizen could complete the viewing in minutes and was being provided information directly in the virtual environment. *Boise 11th Street* simply stated participation was "different" using AR/VR. The difference they mentioned was caused by interactivity in the VR environment. Respondent A discussed longer and more thoughtful feedback after citizens took the devices off. The self-guided format of *Boise 11th Street's* rendering found citizens to be more engaged and provided better quality in feedback:

> "It seems that the engagement is different. They [the citizens] seem to be more engaged just because they have a tool that they're having to man themselves and that is completely new to them. It's just very different than going to a poster board and looking at it. There's no like interaction with it. I think because VR has some level of interaction it just naturally draws them in and creates better feedback." Respondent A.

For *Lethbridge ELUS and SASP*, respondents D and E felt there was slightly more participation but were unable to attribute it to AR/VR. However, they did see the quality in feedback change because of VR:

> "I think there was a slight change in the quality of feedback, like it was improved by AR/VR, but I wouldn't say the quantity." Respondent E.

Respondent D discussed certain aspects of the project were highly complex, with the VR visualisation providing context and a conceptualisation of the project. They argued VR helped citizens understand the project, leading to more informed feedback.

Respondent I from *Reimagine Robinson Street* mentioned citizen obtained more information from the VR renderings, compared to traditional visualisations. This resulted in slight changes to feedback. Further, they argued that VR enabled engagement and participation because "it's a different format of communication. It's a tool to communicate ideas and I don't think any other tool gets to that the level of experience".

From *Seattle HoloLens*, Respondent F and H found feedback was quicker when using AR. It was said that during traditional settings, the participation process is longer since citizens have issues understanding complex issues through photographs or maps. When implementing AR HoloLens, citizens were able to understand these complexities much quicker, along with asking less questions, leading to a faster feedback process. Respondent G said that novelty was an important in recognising changes to participation. They found citizens were joyful using AR, which made them more open to providing feedback. However, the nature of the feedback or quality was unchanged:

> "Most people very quickly volunteered their reactions because they were doing something novel." Respondent G.

4.1.4.2 Online and At-home Participation

Many government projects have adopted online or internet-based tools, allowing citizens to participate and view project details at-home. AR/VR is an entirely computer-based visualisation, making it easy to upload any information, data, or rendering online. For this study, each case except *Seattle HoloLens*, uploaded the renderings online, allowing citizens to view and submit feedback at-home. Online participation was not the main method of feedback collection, as in-person was still the preferred. Overall, respondents who used an online platform found it beneficial to disseminate project information on the internet for citizens to access. *Reimagine Robinson Street* and *Boise 11th Street* decided on IRIS VR for their online hosting platform. This hosting service allowed the uploading of 360˚ videos or renderings which could be downloaded on a phone or computer. To view the virtual environment, it could be done with or without an AR/VR device. From there, citizens could access the renderings and forward comments regarding the project:

> "The website [IRIS VR] allows you to upload a 360-panorama image and puts it in a format where you can download their app on your phone and then you can slip your phone into the headset and you're ready to go." Respondent I.

Lethbridge ELUS and SASP decided to upload their videos to YouTube. Their 3D renderings were in a video format, making it an easy decision to use YouTube as the platform as it is compatible with 360˚ designs. Further, they can be viewed without a VR device. This case created project webpages including links to the videos, feedback from in-person meetings, and plans, forms, newsletters, and official documents created by the city. For citizens to provide feedback at-home, they made surveys available online which were directly sent to the city:

> "The different scenarios for the ELUS/SASP projects are on YouTube and you can do 2D or 3D. You can put your goggles on and watch it online. It's hosted on our [the city's] YouTube channel. […] Our website has all the documents from the project and a survey for people to fill out." Respondent E.

For *NRVR*, the case began its participatory stages after the start of the COVID-19 pandemic. Due to restrictions on social distancing, they created a massive online participatory system. *NRVR* built an online system that enables citizens to participate in the comfort of their homes, which is beneficial during a pandemic. Their online platform allows citizens to see project details, renderings, and scenarios. Citizens can provide feedback while viewing the project plans or after:

> "There's definitely a benefit in my eyes because of what we did face last year [COVID pandemic]. This gives us a platform where we can show the developments to people at the comfort of their own computer. The platform makes its easy to put these VR renderings on this website for anyone to see. You also have a population of the community that may not necessarily want to come to a town, city council, or planning board meeting. However, they would be happy to provide feedback through the comfort of their own chair at home." Respondent C

4.1.4.3 Citizen Co-produced Renderings

Lethbridge ELUS and SASP and *NRVR* were the sole cases discussing renderings being created in a co-produced space. *NRVR* mentioned this was a method they were adopting into their participatory process, whereas *Lethbridge ELUS and SASP* talked about it as a potential benefit to AR/VR. For *NRVR*, citizens gave feedback preliminary visualisations and current aspects of their city. Feedback was based on what they believed requires change. From this feedback, the city developed renderings as possible scenarios of future projects. This method of rendering creation allows citizens to be more involved in the development process, and produces a space of co-production between citizen and government. This intends for citizens to have a greater say in decision-making:

> "What we want the renderings to look like, is a result of the feedback that we receive from the community in that area. We've been criticized for over many years for not building for what the community wants." Respondent C.

As for the *Lethbridge ELUS and SASP*, Respondent D brought up having a real-time creation of renderings during a consultation or participatory meeting. It has similarities to *NRVR*, however, instead of occurring over the course of a designated participatory process, these renderings are created real-time while citizens are providing feedback. Since this project completed in 2015, the AR/VR technology at the time limited the creating of a visualisation real-time. Now it is more practical, considering the advancement of the technology and the introduction of game engines into 3D modelling for urban planning. The idea from Respondent D sprung from a Canadian Institute of Planners conference, where a facilitator could create a rendering over the course of a two-hour workshop:

> “The entire workshop was two hours and in two hours, we went from a discussion on a hypothetical project, to a rendering. At the end, we had a VR concept. It was amazing to see.” Respondent D.

4.1.4.4 Novelty

AR/VR technology is new to participatory practices, and has only recently become more accessible and adoptable. Novelty, in the sense of participation benefits, relates to the new experience citizens have with a technology they are unfamiliar with, along with the generation of excitement. Respondents found citizens were more intrigued in the project when being offered the AR/VR device, and “created a buzz” (Respondent F) around the conversations and proposals.

Respondents indicated that most participatory, decision-making, or governmental processes are mundane. They argued that it is rigid and predictive. Respondent B mentioned having “a hard time engaging the public on any planning conversation”. Later in the interview, they decided on using VR because “it was more engaging, more interesting, and novel.” Respondent C described participatory meetings as “sitting through hours of somebody talking about the project, which is no fun”. Further, the argued that the use of VR was “a no-brainer”, as they claimed it added something fun, interactive, and exciting to the process. *Lethbridge ELUS and SASP* described interactions with the technology as leading to more excitement in participating. *Seattle HoloLens* discussed the novel nature of AR as a reason for its implementation into their participation meetings. *Reimagine Robinson Street* mentioned citizens have difficulty being intrigued by the participatory process because it is repetitive. Having a VR kiosk for their project made citizens “fascinated by this new thing and they were more excited to try on the headsets or Google Carboards and become engaged” (Respondent I).

Cases intending on using the novelty of AR/VR to generate intrigue and excitement, in the end, found that excitement was generated and citizens were more intrigued using AR/VR devices than looking through photographs and maps. Enthusiasm also helped certain officials. *Seattle HoloLens* and *Lethbridge ELUS and SASP* mentioned themselves and their colleagues were eager to try the technology out with their constituents. Respondent G mentioned this enthusiasm led to them finding “a new way for us [the city] to engage citizens with this stuff [bylaw amendments]”. Overall, the novelty of AR/VR benefited the participatory process by making it more intriguing and enjoyable.

Lastly, one single instance saw novelty increase participation. In *Seattle HoloLens,* it led to more people willing to participate:

> "Most people very quickly volunteered their reactions because they were doing something novel. We only had a few hours at each meeting where people could use the devices and each time, they were being used the entire meeting." Respondent H.

Although novelty produced an enjoyable experience, increased participation was only mentioned by *Seattle HoloLens*.

4.1.5 Other Benefits

Since this study uses a comparative methodology, the five cases were compared to find similar or different benefits. This final category addresses benefits resulting from one specific case.

4.1.5.1 Open Sourced

NRVR is making their process, software/renderings, source code, and any content related to the technology portion of their project, open sourced. Open sourced is a process where contents from the project are freely available, distributed, and open licenced, meaning contents can be easily accessed, modified and are not restricted to certain software (Perens, 1998). *NRVR's* intention of making their project open sourced was a requirement by Bloomberg Philanthropies. This case was the largest in terms of budget, scope, and future use. Making it open-sourced becomes exceedingly intriguing for how it can be adopted and modified by other governments:

> "I think municipalities could benefit from what we've called our tool kit, to have open-sourced software where we can share this technology with other municipalities. I do think that other municipalities around us can benefit from it." Respondent C.

Since the project is still underway, the respondent was unsure how their work would be distributed. However, they understood the potential benefits of creating an open-sourced project. They mentioned that it could make AR/VR easier to adopt, and significantly cheaper. For smaller municipalities who are budget constrained, having a multi-million-dollar project which is open-sourced and freely available to modify and alter would benefit them by saving costs and time.

4.2 Challenges

Similarly to the *Benefits*, the interviews found challenges in four main categories: citizen, government, technical, and participatory (see Figure 8). Each category breaks into specific challenges found from the five cases. Discussions resulted in finding aspects related to the *Future of AR/VR*, which has been created into a separate section. Comparable to the benefits, a final category of *Other Challenges* will be presented.

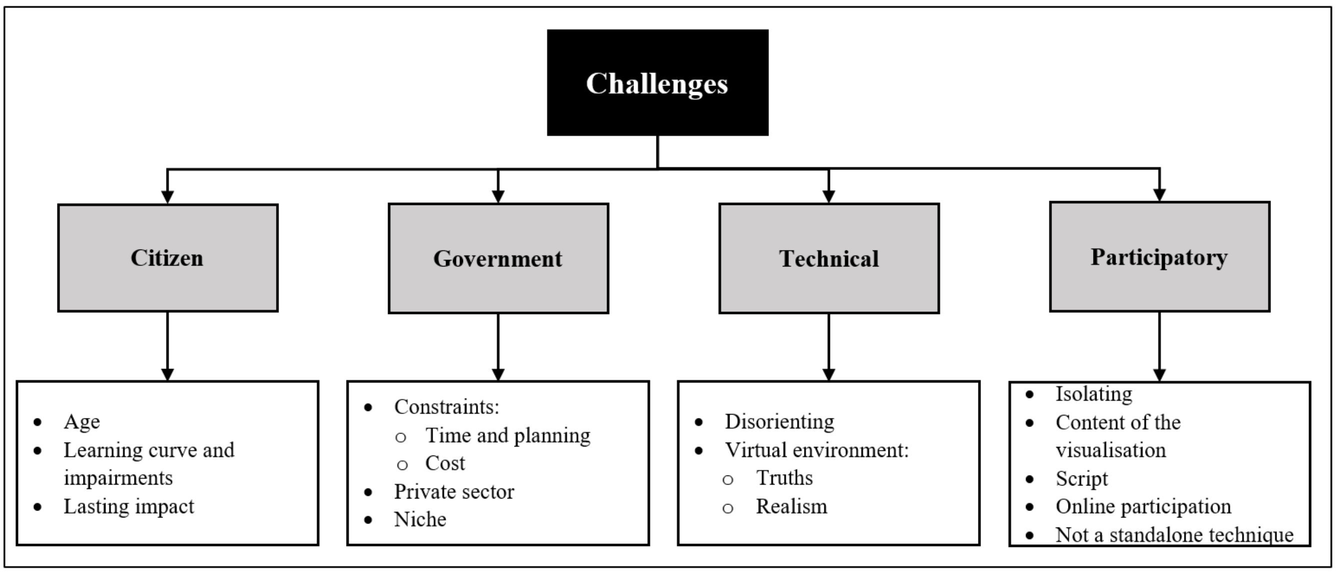

Figure 8: Challenges of participatory AR/VR.

4.2.1 Citizen Challenges

A theme of challenges found was issues pertaining to citizens. Respondents found that AR/VR had no lasting impact on citizens, implying that the technology was not meaningful to citizens. Further, a learning curve and visual impairments made it difficult for some citizens to work the devices. Lastly age was a factor in getting people involved, where older people struggled with the technology.

4.2.1.1 Age

Age is an important factor when discussing a new form of technology. It was mentioned in the *Benefits* section that the technology is advantageous for younger generations, who understand and are more inclined to try it. The opposite was found for older generations. They were still intrigued by technology, but cases found they were dismissive and had difficulty believing the rendering was a visualisation. *Lethbridge ELUS and SASP* found older generations knew less about the technology, and it impacted how they felt towards experiencing it:

> "I think it's [VR] generational. My generation and younger seem to get more excited about it, like video games. Whereas older people, they don't really seem to know much about it, aren't as excited about it, and might not want to try it." Respondent D.

They felt adopting VR affected older generations in a participation setting, since they were less incline to try it. Further, on their own time at-home, many older participants "weren't interested in viewing the VR rendering as we [referring to younger people] were". They argued it was about perspective, as many older citizens prefer traditional photographs and videos because they lack an understanding of virtual technologies.

Seattle HoloLens discussed older citizens being dismissive of the technology. They noted that older citizens are drawn into participatory meetings more often than younger people. From this older group participating, they found certain citizens were outright dismissive of the technology, expressing how they thought it was ineffective as a visualisation, and outright denied trying it. Further, they found some young people were not excited about their AR visualisation. It was reasoned that younger people are accustomed to this technology and have most likely used it before, therefore it is not novel to them:

> "I expected young people to get more geeked out on it but then I realized they're exposed to more of that stuff [AR/VR] all the time. Seniors aren't playing these video games. A lot of seniors would straight-up say 'no' when we asked if they wanted to try it. I think a lot of that has to do with not knowing what AR is." Respondent H.

Respondent B from *Boise 11th Street* found the technology would drift people away from the real purpose of the visualisation. They mentioned certain age groups questioned the integrity of the rendering, and the purpose of using virtual technology:

> “Instead of asking questions about the project, they were asking about the technology, and ‘what exactly am I supposed seeing here, what's the upshot of all this, all it is, is a pretty picture’.” Respondent B.

4.2.1.2 Learning Curve and Impairments

To function, AR/VR technology requires a device. This requirement runs into challenges that impact citizens. One challenge is the learning curve behind controlling a device. Seattle *HoloLens* used voice activation which was considered “clunky” and difficult to work with. Another challenge impacts those with sight impairments, where specific devices are unable to accommodate users with glasses. If a citizen has such an impairment, they might not be able to see or experience the visualisation properly.

The HoloLens device, designed and created by Microsoft, was used by *Seattle HoloLens*. An interesting aspect of this device is its capability of voice activation. For this project, citizens would say “next view”, and the device would change the scene. Respondent G and H found the voice activation was tricky. Sometimes citizens were not able to understand what it meant to speak to the device and others had issues with the technology’s accuracies of recognising their voice. The respondents found it frustrating that an expensive technology had such a critical issue. At times, Respondent H had to “stand behind the person in a rear hug and talk through the commands for them”. Respondent G went on to describe the voice commands and its challenging nature:

> "The voice commands themselves were challenging. The way it worked was we had three or four contrived neighborhood views and you had to speak into the HoloLens and say ‘next view’ to move to the next one. All of that was just really wonky. Anything would have been better than messing with those voice commands.”

Seattle HoloLens and *Reimagine Robinson Street* discussed visual impairments. It was mentioned that anyone with glasses struggled using the VR device, since most headsets are not compatible. Respondent I from *Reimagine Robinson Street* wears glasses and they expressed frustration with the devices. During the meetings, citizens with glasses wanted to try the VR devices but were unable to, which made them feel excluded from the participatory process. With some devices, they could adjust the focus, so certain citizens with a visual impairment could see without glasses, but it was not always successful:

> "One challenge was not a lot of people who wear glasses were comfortable with putting on the devices. Some devices are hard to use with glasses. There are headsets where you can adjust the focus and the length of the lenses, but it gets tricky in a public setting where each time we have to adjust it." Respondent I.

4.2.1.3 Lasting Impact

Seattle HoloLens and *Reimagine Robinson Street* found citizens were initially excited to try the technology, however, using AR/VR had little to no impact on their overall experience of participating. In these cases, citizens found themselves interested in the technology, but they cared more about the project than the experience. While the experience was fun and novel to the citizens, to some of them, it was another visualisation. Respondent I from *Reimagine Robinson Street* mentioned citizens would be interested in the participatory meeting, but not the VR technology. They cared more about participating, than remembering the tool they used to participate. When asked about the possibility of AR/VR having any impact on the decision-making process, Respondent G responded by saying:

> "If you asked a random person what the most memorable or meaningful part of how you participated, I don't think the HoloLens would be what's rising to the top."

4.2.2 Government Challenges

Government challenges were common amongst the cases. The recurring conversations were constraints of time to make the renderings and their relative cost. Further challenging governments is their lack of technological capabilities and understanding. Respondents discussed a small private sector, making it difficult to find a consultant capable of building AR/VR visualisations. This issue allows certain companies to charge a high price for a sup-bar final product. Finally, the niche nature of AR/VR, at times, pushed respondents to convince their colleagues and constituents the benefits of the technology.

4.2.2.1 Constraints

Government constrains are identified by time and cost. Time to the lengthy process it takes for renderings to be made. Cost correlates closely with the constraint of time, but is mostly effected by the cost of the technology itself, in creating the renderings, and possessing the peripherals and hardware.

4.2.2.1.1 Time

For governments, time is an important resource in developing and running their decision-making process. AR/VR renderings take time to create, which can further delay the project and force governments to look for other participatory tools. *Seattle HoloLens*, *Reimagine Robinson Street,* and *Lethbridge ELUS and SASP* discussed the slow process of working with AR/VR, from the finding of a consultant, to having a final product. Within this time constraint is a requirement to plan the creation of the visualisation. Since building an AR/VR environment requires more time than usual, this is taxed onto an already time-consuming process.

Respondents from *Seattle HoloLens* discussed the work and time it took to complete their vision. The general response regarding AR and HoloLens was it required a high degree of work and did not meet expectations. Respondent F mentioned that the entire process of conceptualising their project to the final rendering was extremely time consuming, going well beyond traditional visualisations. They provided an example of adding a tree to the rendering, something which sounds simple, produced compatibility issues, and slowed down the entire creation process. Respondent F compared creating the rendering to “building a train set model, tweezer by tweezer”. Further, it was discussed how the time, cost, and cantankerous issues they faced using HoloLens was not worth the effort as a participatory tool:

> “In the bang for the buck category, I think there was tremendous amounts of work and sleepless nights to make it function.” Respondent F.

Reimagine Robinson Street mentioned an AR/VR rendering has more detail than a typical 2D visualisation. Respondent I described AR/VR having requirements to include everything that is around them, and not what is in the viewers immediate frame. If a 360˚ environment only has static image, with nothing in the horizon or behind the user, it creates an unrealistic depiction of the real-world, so everything must be modelled. To make the environments realistic, it must include everything, from trees, bushes, parks, lampposts, not only in the immediate frame of the user, but everywhere around them. This challenging and time-consuming and difficult:

> “In a typical photograph, you're just looking at one shot, one frame and you're only worried about what you see in that frame. When you're creating this in a 360˚

environment, you need to model the whole environment even what's behind you because somebody could turn and they could see it. You need a 3D model of the whole environment so the buildings, the streets, the parks, rivers, cars. So that adds a lot more work to your 3D model." Respondent I.

There is a requirement of early and thoughtful planning before adopting AR/VR. This stage was argued as a "make or break" (Respondent A) aspect of the AR/VR implementation process. Respondents from *Boise 11th Street, Seattle HoloLens*, and *Reimagine Robinson Street* mentioned a rigorous planning process before any visuals are made. If skipped, the visualisation becomes more expensive, time-consuming, and less realistic. Respondents argued that when a lengthy and difficult planning process is required to make the visualisation, it can cause AR/VR to be overlooked for other techniques. Respondent H knew lots of front-end work would be involved to get the project started, stating that it required a large degree of planning compared to their past visuals. Respondent G from *Seattle HoloLens* described their workflow process. They made sure to prepare a course of action since it was a technology unfamiliar to them. It was described as "missteps" whenever something was not going as planned. Since it was their first time working with the technology, each mistake would slow down the process:

> "Anytime you're going through a linear process from your starting point to your end point, and you're taking each step for the first time, with one misstep you are already behind and will struggle getting back on track." Respondent G.

Reimagine Robinson Street followed an early planning stage to their development. Respondent I discussed the challenge of finding an online hosting service that easily manages 3D environments online. Finding this service was described as "challenging to identify what type of platforms we can use, because not everything can open on a phone or headset" (Respondent I). Further, they mentioned that AR/VR is an entirely technological product, meaning planning must be done months in advance. Without planning, the final product will lack atmospheric details (items that connect the rendering to our real-world, such as shadows, trees, cars, textures on buildings) and issues will arise on the day it is presented (technological problems). Respondent I found planning must be done as front-end work, otherwise it will be costly in terms of time and money later in the process:

> "One lesson I learned was we need to plan for using VR far in advance for public meetings because if you don't, then the 360˚ environment will just be a plain 3D model with nothing special about it. It adds a lot of time and money to create these [renderings] especially if you haven't planned for it. So, you need to budget and plan for it up front."

Respondent A called the early stage of planning storyboarding. They described this as a workflow, from beginning to end, that addresses what they want the visualisation to be and what it should include. They discussed a detailed workflow process as a lesson learned resulting from their project, where they advised to "create a storyboard that shows what it is you want to achieve, because it will help define the amount of effort and money you want to put towards it" (Respondent A). This necessity of storyboarding was based on how much detail is required to be included in a virtual environment. There is more to an AR/VR environment than what is seen directly in front of the user. If planning is lackluster, they argued that the virtual environment will miss valuable details and become more time-consuming.

4.2.2.1.2 Cost

Cost for governments is important since projects are restricted by budgets. From a government standpoint, AR/VR costs money that could be difficult to find. Even for citizens, if they see a high price-tag required to implement the technology, they could spin the idea as spending excessive amounts of money on something that could be spent elsewhere. Respondents discussed the tricky line that AR/VR stands on, in terms of cost and what it offers. The cases proved cost as the most constraining aspect of AR/VR and was the challenge discussed first by respondents. The finding of cost relates to the expensive nature of creating 3D models, renderings and visualisations, and the required peripherals.

Lethbridge ELUS and SASP found cost was a massive barrier which limited how realistic the rendering was and how long it took to build. The respondents described AR/VR being constraint driven, where at this moment, the technology's biggest challenge is its cost:

> "I think cost is a barrier. If we could have all the money in the world, we could have made the renderings even more close to what reality looks like today, but cost was definitely a challenge that we had to figure out. We had to find a balance

> between quality and how long, how much it costs, and how fast it would take to get done." Respondent E

Respondent E went on to mention that "costs would have to come down so that the technology is more widespread". Further, they discussed Lethbridge as a risk-adverse community, where adopting something new and expensive is often overlooked since they do not want to risk irritating constituents or developers. The respondents wished they could work with the technology again, but Respondent D said it would be difficult because they "don't have the resources in terms of time and money to do much".

Lethbridge ELUS and SASP mentioned wanting to build an arsenal of 3D data, from building models to density massing files. However, the cost, maintenance, and being capable of creating the data, was impossible for such a small city limited by their budget and technological sector. This can be said for other small cities, who are not capable of managing 3D data because of resource constraints in handling, dissemination, and creating the files:

> "Something here [Lethbridge] I would like is a 3D model of the entire city, which of course isn't possible right now because it would be lots of money. It'd be nice to get that and then base future projects off of it." Respondent D.

Seattle HoloLens created some models and renderings themselves, calling it a "start-up cost if we ever want to do this type of thing again" (Respondent F). Since they worked with existing models, they were able to save some preliminary costs. Their biggest concern were the expensive peripherals required to experience an AR visualisation. This case used the Microsoft proprietary HoloLens devices, which have higher costs than their AR and VR counterparts. Respondent H wanted to have more kiosks of the devices, to upscale the entire experience, but they "didn't have the budget for it". Further, respondents found they were frightened by the prospect of breaking a device, which was something they could not afford:

> "We needed the third-party vendor to be with us because those things [HoloLens] are very expensive and the idea of us working with them alone would have sent panic through our little budgetary hearts." Respondent F.

Further, AR as a technology is not necessarily expensive, but their adoption of the technology was. HoloLens was found to be overly expensive for what it provided. Respondent H found AR was beneficial, but how they "used the HoloLens is just way too expensive to make it worth it." They finished their discussion on AR and HoloLens by stating:

> "I think you're right, Respondent G, not to overstate any of what we did with HoloLens. Only that there was something fun about it and not really being worth the money." Respondent H.

Boise 11th Street mentioned that "the biggest concern with VR is its apparent cost". They said it impacts adoption of the technology, where governments focus too much on the cost and compare it to what the technology offers. Further, respondents A and B believed that education on the technology within governments would alleviate the constraint of not understanding the true nature of what the technology offers. Educating and understanding the technology will be discussed with more detail in the *Other* section.

Reimagine Robinson Street briefly mentioned that governments keep to small budgets that cannot accommodate AR/VR. This finding has similarities to *Boise 11th Street*, where the response focused on a misunderstanding of the technology. Some governments "might feel this [VR] is not really that helpful and kind of a waste of more money that they don't want to spend" (Respondent I). Further, they talked about how it depends on the government's intentions, saying "some agencies might want to try it, but it depends on how much more cost and time they are willing to allow" (Respondent I).

The final case to mention is *NRVR*. While no explicit comment was made regarding the constraint of cost, it is clear that they required a massive budget to create their VR renderings and online platform. Respondent C mentioned that the overall budget for the project was near $16 million. Compared to the other cases, most of the projects ranged from $25 to $200 thousand. The entire budget was not made clear, but it was mentioned that a decent portion went towards the creation of the renderings and the mobile kiosks. Their budget to create the renderings and have multiple mobile units with high-end VR equipment shows the expensive nature of VR. Since the defining factor of this case is to become an open-sourced project, much of the primary costs will be saved if cities adopt it. However, the requirement of the devices is still apparent and can be costly.

4.2.2.2 Private Sector

Respondents discussed a challenge finding consultants who were able to create an AR/VR experience. Finding a consultant is sometimes necessary due to government services not being sufficient in producing an AR/VR visualisation. Some cases, such as *Seattle HoloLens* and *Boise 11th Street* were able to reuse models they had already created, but for *Seattle HoloLens*, the city's capabilities lacked the requirements to make the visualisations.

Respondent A from *Boise 11th Street* characterised the private sector as subpar. The reasoning behind this argument was AR/VR has not reached a tipping point in being a mainstream participation tool, which limits the private sector. Since there is a small pool of consultants who work in the field, prices have inflated for work that was described as subpar:

> "There are some really bad companies out there that are charging an exorbitant amount of money for their quality of work that I think is subpar. It actually hurts the practice in a way. It says 'oh this is going to be expensive' but in reality, there are ways to make it not expensive." Respondent A.

Lethbridge ELUS and SASP faced challenges in finding a consultant capable of creating the rendering they required. There were issues at the company, as the specialised employee left halfway through the project, resulting in a more stressful and time-consuming process. Further, after the completion of the project, the original contract signed between the city and Stantec mentioned that any raw files were to be sent to city so they could use them how they wished. At first, the company was not understanding of the contract and tried providing them with alternatives. However, it was solved, and the city received the raw files, but it left a negative impression with Participant D:

> "He [specialised employee] sent it off to his boss and his boss was difficult to deal with because he didn't really understand the contracts that they signed. So, he didn't want to send us the raw files and just wanted to send us a video but, in their contract, they agreed that they would. He was really difficult to deal with but eventually after

> a lot of prodding and reminding them that, 'no it's a signed contract saying you will give us these files', that he sent them to us. Overall, it was a challenge."

Further, respondent E mentioned that "once more technicians who are capable of working with the technology, then the cost will come down and the quality will go up".

Reimagine Robinson Street had a similar response to Respondent E from *Lethbridge ELUS and SASP,* which was regarding the current challenge of accessibility surrounding the technology. They understood that presently, very few people know how to create AR/VR renderings, and few firms offer the specific type of experience within the realm of a participatory tool. Respondent I said that for the technology to become more viable, accessibility must increase, which they argued depends on the private sector:

> "I think the challenge is to make it more accessible. Right now, very few people have the skills to develop these renderings. I know some firms are using it now, but even within those firms there are very few people who can actually do it. So, hopefully with time it becomes more accessible."

4.2.2.3 Niche

In AR/VR's current state, respondents found they were selling the technology to their constituents. Meaning, they exaggerated the potential benefits of the technology, trying to convince citizens and colleagues. This represents the technology as a niche. Respondent A from *Boise 11th Street* said that the issue is caused by the technology not being mainstream. Currently, it is not a conventional technology for participation, and was argued that the technology must be over-marketed to be adopted:

> "I would say the VR and AR technology is not in the mainstream. A lot of what we've done so far has been really trying to sell it by offering up some cool nuggets of the technology, which brings people more on board with the idea." Respondent A.

Similarly, *Reimagine Robinson Street* described the technology as a gimmick by convincing citizens of its benefits. Even though Respondent I believed the technology is a good tool for visualising change and communicating complex ideas, it is not an ordinary or conventional way of providing information. Since it is not mainstream, Respondent I found that AR/VR is often used as a publicity stunt, more so than a content piece:

> "I think one weakness is the technology may not be there yet. It is kind of an additional gimmick that you can do, and people get excited about it but I'm still not sure how much real value it adds to these projects. I can't stress this enough, is people just kind of use this as a gimmicky tool, more so than a content piece. It's a challenge to go beyond that."

It was added later that in the future, AR/VR can accommodate more realistic virtual environments in using audio and interactions. Once this becomes conventional in AR/VR, then it will be less of a gimmick and more impressive for its content.

4.2.3 Technical Challenges

Technical challenges were found based on certain characteristics of the technology. Citizens became disoriented and sick when viewing the experience. The immersion and lack of realism in the renderings affected citizens' understanding of the virtual environment, further altering the truth in the visualisations.

4.2.3.1 Disorienting

Wearing a device that affects your vision by replacing it with a virtual environment, can be disorienting. Citizens and respondents found wearing the AR/VR headset made them feel nauseous, dizzy, and caused a sense of disorientation. Further, with the case of *Seattle HoloLens*, they found that their AR devices warped the visuals, causing citizens to question the accuracy of the rendering.

Reimagine Robinson Street found that wearing the VR device for several minutes, made them and citizens feel dizzy. They mentioned that people became dizzy and sometimes nauseous because of a difference in framerates. While no audio was being played alongside their rendering, Respondent I discussed how the movement in a VR device can cause inner-ear motion sickness:

> "One challenge was, even for me, once you have a headset on a couple of minutes, it gets dizzy. You try to move around, and the frames don't move at the same speed. The frames change but not as well as your natural eye movements and that creates this disconnect between you moving and what you see."

Since this was an issue known to them prior to the participatory sessions, they made sure citizens could still view the rendering on a laptop or iPad. Respondent I went on to state that being disoriented in the VR device is a challenge that cities need to plan for, otherwise citizens will have a negative experience of the technology.

Respondent A from *Boise 11th Street* went into more detail on being disoriented as an issue in a VR experience. When asked about lessons learned from their project, they described issues regarding dizziness and disorientation. Some citizens tried kneeling or sitting while wearing the device but would fall over. This was caused by a lack of spatial awareness while using the device. It was said that, at times, it was a safety hazard having citizens use the devices while outside:

> "Putting on the goggles and then you start moving around, it messes with your inner ear. You have to think about people's safety when they're putting it on. You don't want them just to keel over. That's probably one of the less obvious challenges. Someone needs man the VR goggles so that you're there to catch them [the citizen]." Respondent A.

Respondents from the *Seattle HoloLens* mentioned that even though they knew the AR renderings "were accurate to the inch" (Respondent G), the HoloLens devices warped the renderings. Respondent G found it difficult to describe the feeling. They knew everything was geometrically perfect, yet when they tried the devices, something felt wrong in how it was being presented. Further, this disorienting effect made citizens less inclined to believe what they were being shown. Respondent G described this issue with HoloLens as a foreshortening effect:

> "I remember people who just found it a little disorienting and didn't buy it. Some people were like 'I feel like I'm way too close, way too far', or they'd say, 'there's no way that's a 10-foot setback.' I'd be like it has a foreshortening effect. The whole

> point was to immerse people in this more realistic view of our project, but it made people get distracted by this weird distortion."

Respondent H agreed and further criticized their rendering by calling it unrealistic, which caused disorientation. They felt their rendering caused citizens to be disoriented and disconnected from the virtual environment because it lacked realism. Respondent H called it a "fake world", when "there's no texture and detail, it becomes disorienting".

4.2.3.2 Virtual Environment

The virtual environment of an AR/VR experience has certain challenges. One apparent issue is the truth behind the rendering. There is a level of realism and trust ingrained in the creation of a 3D visualisation. The more realistic the rendering, there is greater promise to what the final design and project will look like. If the final product is not similar to the AR/VR rendering, trust between citizen and government becomes an issue for future projects. The second issue is how realism effects the citizen's experience. If there is a lack of realism, citizens have difficulty connecting the virtual environment to the real-world.

Boise 11th Street explained that 3D visuals are not always truthful of the real-world and the final product. Respondent A argued that 3D visualisations can be fantasy and have fake textures to make them look pleasing to the streetscape. They mentioned that it is something people must understand and be prepared for:

> "This stuff [VR] can almost be just like a video game and video games can be fantasy right, so is this true to reality?"

Respondent B built upon this by discussing government promises. A government should not overpromise or underdeliver, they must perfectly place the visualisation in the middle. Further, the participatory process needs to be an honest form of communication, something that can be affected by the false promises in AR/VR:

> "Do you over promise with your design or your rendering/visualization and then under deliver with the actual product? You can paint pretty pictures with all these

> trees and other things, but the reality is, when the project is done, you're getting zero landscaping. If people feel like they've been lied to that's going to really knock down your trust later on. Just be honest with your communication in every phase of the project." Respondent B.

Reimagine Robinson Street described an issue regarding the portrayal of their renderings and visualisations. Coming from a background in architecture, they stated that architectural renderings emphasise fakeness, by "making the renderings look glitzy, but when it's actually built, the building is crappy". Respondent I went on to talk about "photoshopping" the renderings to make them look impressive. This technique causes the rendering to have little resemblance of the real-world, where rain, fog, and sunlight are atmospheric conditions rarely placed in a rendering. They struggled in communicating the vision of the project, questioning if they should oversell the development, or keep the rendering to as realistic as possible to the final product. Respondent I expressed the potential to mislead citizens with AR/VR because they are in control what is included in the virtual environment:

> "There's a balance between what we're trying to show as a recommendation and vision, for what we think it'll be. I struggle with this a lot. It's about whether you produce these renderings to communicate a vision which is kind of grand and ambitious and maybe aspirational versus what'll end up being a reality. There is more potential to mislead people with some of this technology because you have much greater control about the whole experience rather than just an image."

An important finding from the interviews is the significance of realism. From *Boise 11th Street*, Respondent A mentioned future visualisations must have a greater extent of the 3D environment. A virtual environment should be inviting to the user and have a natural feel so they can become immersed. If this element is lacking, it takes away the impact and experience of VR. Respondent A described this importance as a lesson learned from their project:

> "One of the biggest lessons is about creating a 3D model. It's like 'how far do I create the extent of my 3D model'. When you want to put the goggles on, you want to try to avoid creating that look of nothing but flat earth. You want it to have some

> natural feel so that the earth doesn't end in your VR. You want the scene to be realistic and without it, it's just missing that extra something."

Respondents from *Seattle HoloLens* found a lack of realism caused difficulties for citizens to connect the project to the real world. Their rendering was a static image, where everything was stuck in place, such as a skateboard in midair. They mentioned a disconnect occurred due to the static nature of the visualisation. Mentioned in the *Benefits* section was Respondent H's discussion on personal cues of their environment, and how they help keep a person grounded to reality in the visualisation. Further, Respondent H discussed losing this cue once realism was missing in their virtual environment:

> "In our model we had a skateboard, but it was frozen in midair where you're like what happened here, was a bomb dropped? It looked like everything went into a frozen state and was pretty unrealistic. You lose this cue to your environment." Respondent H.

Respondent G agreed with this statement and said that "it felt very much like a picture that you were walking through". Later in the interview, they mentioned that the AR rendering closely resembled a computerised photograph, which was not their initial intent. They stated: "it is not the same as walking through an augmented reality that is immersive and interactive, when it's just a photograph" (Respondent G). This alludes to the challenge of realism. If realism is missing, citizens can be disconnected from the visualisation, becoming uninterested or unsure of what they are seeing. Respondent H found realism impacted how citizens felt within the experience. Since their rendering was unrealistic, it disrupted the citizen's notion of scale, making it difficult to place themselves in the virtual environment:

> "You're in a fake world and when you look down the street and it goes into nothingness, it's very disruptive to the notion of scale because there's nothing else in the horizon, to help you stay in a scaled world." Respondent H.

Finally, building upon the *Time* section of challenges, Respondent I stated that AR/VR visualisations require an entire 360˚ environment. Since the citizen is not looking into an immediate frame, photograph, or extent, everything around the user must be created. This requirement demonstrates the importance of realism on immersing the citizen. If the environment is static, similar to *Seattle HoloLens* with no horizon or background, then the citizen disconnects themselves from the visualisation. This emphasises the importance of a realistic and fully developed virtual environment:

> "The 360˚ environment needs to be filled, such as the blank space behind you. If that isn't there and the user turns and sees nothing, it really takes them out of the entire experience." Respondent I.

4.2.4 Participatory Challenges

Participatory challenges pertain to issues of AR/VR that impact the participation process. The isolating characteristic of AR/VR limits face-to-face interaction in a participatory setting, making it an individual experience. As a participatory technique, AR/VR does not function by itself, it must have other visualisations accompanying it in a participatory session. Further, AR/VR requires devices to function, limiting online participation.

4.2.4.1 Isolating

Respondents expressed a participatory challenge due to the isolating nature of AR/VR. When a citizen was in the experience, and if no script or guide was used, there was little communication possible between citizen and city officials. The citizen was pulled out of the participatory meeting experience. Communication between everyone in the participatory setting is crucial for feedback production, something that becomes complicated when citizens are put in an isolating tool. *Seattle HoloLens* and *Boise 11th Street* commented on the isolation. *Boise 11th Street* found their VR experience was user-guided, making communication between official and citizen difficult (Respondent B). Since the respondents were incapable of seeing what the citizen was experiencing, there was difficulty understanding the feedback citizens provided.

Respondents from *Seattle HoloLens* expressed the isolation was a reason why HoloLens and AR/VR are difficult to be accepted as participatory tools. Respondents F and H mentioned that citizens who were waiting their turn to use the devices, were standing, unable to engage with anyone around them because the user was the sole person in the experience. They should have projected what the user was seeing to everyone, so it felt more like a community meeting, than an individual type of participation:

> "With HoloLens, it's strangely isolating. No one can see what they are seeing, and everyone just stands in silence waiting their turn. I kept thinking it would be great if we projected what people were seeing on a screen so that everyone got to enjoy that person's experience." Respondent H.

When asked about the viability of AR/VR as a participatory tool, Respondent F based their experience of HoloLens, stating that it does not have participatory capabilities. They discussed how "it was such an individual experience that you have to pull the feedback out of citizens". Respondent F compared AR to traditional participatory techniques, such as photographs or maps. They found traditional forms easier to engage with since there is open communication. Citizens are beside each other and the "first instinct is to say hi, then you are off to the races". Compared to AR, it was described as "taking you [the user] out of the space", making them less inclined to communicate and discuss:

> "In this virtual space, it's not your first instinct to be like 'hey let's keep talking while I'm in it'. You're literally in a different space that is virtual, so I think some folks aren't inclined to talk through it or to even talk about it afterwards. I don't think it was inspiring for civic dialogue." Respondent F.

Boise 11th Street found it difficult to understand citizen feedback due to the citizen being isolated in the VR experience. Respondent B mentioned the possibility of having the rendering viewed by everyone outside of the device using a projector. They discussed this format as "making it possible to directly understand what they're [the citizen] looking at and what they might ask" (Respondent B), which would help the city officials guide the citizen in the experience:

> "You don't have the ability to see what they're [the citizen] seeing, unless you have one of those setups where you can see what the person's looking at. If you can see what they're doing, you can ask questions about areas where we want feedback. If you can't see, and they ask you a question, they can't just point at it and say, 'hey what is the purpose of this or whatever', they have to describe what it is they're looking at you have to kind of figure it out. It's a challenge." Respondent B.

Lastly, isolation occurs when there is no use of a script or guide to aid the citizen in the experience. Of the five cases, none used a script. Using a script would allow the citizen to focus on the content of the visualisation and not be isolated. Since no scripts were used, citizens had difficulty understanding what was to be viewed. Further, citizens found it difficult identifying areas that required feedback. Since there was no script for *Seattle HoloLens'* visualisation, when citizens gave feedback, the city officials had trouble understanding it. This caused frustration, slowed down the process, and was a challenge. They explained the user-guided experience caused many of those issues. A script has the purpose of maintaining the user on the same path of everyone else, so citizens do not miss important details. Further, it makes the user less isolated, as they are in constant communication with a city official:

> "Because the model is its own curation, it determines what you see and experience. You need other people to be there and say, 'hey what about that', so that you can answer those questions live." Respondent H.

Respondent G explained that they found the feedback process with AR was difficult. At times, citizens were oddly silent, as if "they were waiting for a clear script." They went on to describe the frustration it caused when citizens and officials could not understand each other.

4.2.4.2 Content of the Visualisation

Respondents found citizens focused more on the technology than the content of the visualisations. Citizens were overly focused on the novelty and experience. Some instances saw citizens going through the rendering multiple times before they were able to provide any feedback.

Reimagine Robinson Street found citizens focused on the graphical realism in the virtual environment, causing them to miss the entire content and purpose of the visualisation. Respondent I said that "it is hard to get beyond the graphic qualities of visuals, to get them to look at the actual content, and this is a challenge more so in AR/VR than any other technique". Relating to AR/VR's novelty, Respondent I found citizens were intrigued to view the renderings, but once having the headsets on, "they focused more on the technology aspect of it [VR], than the content". Lastly, there was difficulty getting citizens past the novelty of the technology, to look closer at what the purpose of the visualisation. Respondent I said this will occur once AR/VR is more widespread as a technology.

4.2.4.3 Online and At-home Participation

For citizens to be fully immersed in an interactive AR/VR experience, they require a device. These devices, such as the Oculus Rift/Quest, HTC Vive, and Valve Index are expensive. Compared to a smartphone, they have handheld peripherals which create interactions in the virtual environment. Further, the devices require AR/VR ready hardware in a computer or smartphone, however, this requirement is becoming less costly. *Boise 11th Street*, *Lethbridge ELUS and SASP,* and *Reimagine Robinson Street* deemed the requirement of devices a major challenge to at-home and online participation.

Boise 11th Street mentioned citizens should experience the full immersion possible from AR/VR, however, they realise most citizens do not have own the required devices to make it possible. This means, to obtain the most impactful experience, citizens are still required to attend in-person meetings. Citizens who are unable to intend in-person participatory sessions and do not have AR/VR devices, are relegated to an inferior process at-home. Respondent B described AR/VR devices as a technological constraint, stating that "until everyone has their own Oculus headset at home, people will still need to come in-person". While citizens could still view the rendering on the computer, it lacks the immersion VR offers:

> "A technical and online challenge is if you want to do an immersive VR experience, you still have to get people to a place where you can provide them equipment because not everyone has a setup at home where they can download the file and put on their own VR goggles and check it out." Respondent B.

Similarly, Respondent I from *Reimagine Robinson Street* expressed the same challenge. They characterised VR as a gaming technology, where younger people might have a device compared to older generations. Those who do not own the means to viewing the rendering online, become marginalised from the online participatory process. For the future of AR/VR, Respondent I mentioned governments must figure out "how they can get this [VR devices] available to everyone if they want virtual participation" (Respondent I).

Lastly, *Lethbridge ELUS and SASP* described citizens as less inclined in trying the online portion of their project. Older citizens preferred the in-person setting since city officials could show them how to use the devices. When older generations confront an unfamiliar technology, it generates difficulties in understanding how to access and use the online renderings. Once the citizen is on their own, *Lethbridge ELUS and SASP* found they were less inclined to participate, and preferred attending in-person meetings.

4.2.4.4 Not a Standalone Technique

AR/VR is not capable of being a standalone participatory technique. Of the five cases, none used the technology by itself, it was always necessary to have other visuals. These aids were in the format of pamphlets with information on the project, including photographs, and before and after representations. It was found that these other visuals were necessary since AR/VR limited conversations.

Boise 11th Street explained that AR/VR is not catered to being a sole participatory tool, rather, it must be supplemented. They said that AR/VR "can't be the only thing you do in the engagement process". Respondent A mentioned VR "is always supplemented with other visuals, like poster boards, so that other interactions can happen". Since a challenge of AR/VR is its isolation, *Boise 11th Street* required other visual to replace the face-to-face communication lost from adopting the technology.

Reimagine Robinson Street identified that AR/VR was not a technique which works by itself. They described it as a weakness of the technology, that AR/VR is not yet able to be a sole technique in a participatory process:

> "I think one weakness is the technology is not there yet to be used by itself. We have to still rely on traditional methods." Respondent I.

4.2.5 The Future of AR/VR

Throughout the interviews, respondents discussed the current and future state of the technology. Many argued AR/VR is missing important elements to become successful. A common theme discussed by respondents was their wish to have completed the project now, as compared to a few years ago. Respondents felt only using the sense of vision was not enough to make this participatory format worthwhile, rather, it needs to include visuals, audio, movement, and interactions. The simplest way to achieve this requirement was described as adopting game engines to the creation process.

Seattle HoloLens found their AR visualisations was missing realistic elements. This has been discussed in the *Virtual Environment* section of challenges, however, they felt the technology's future requires more than a visualisation. In their city, respondent F mentioned that buskers are common, however, they were not included in the virtual environment. They said the virtual space did not feel real, since they created a spatial relationship based on the sound of a busker.

Respondent I from *Reimagine Robinson Street* believed the technology was reaching a tipping point, where greater immersion is necessary to take the technology to the next level. This form of immersion was based on an example they provided from the University of Delft in the Netherlands. The project was proposing a bike path, where researchers used VR, a stationary bike, and audio. Citizens were told to pedal on a bike which moved them in the virtual environment. While moving, the environment played audio of cars passing them. Respondent I argued that, since those elements are not commonplace, AR/VR is not capable of being a participatory tool. Further, they discussed that AR/VR requires more senses than vision if it wants to be accepted in a participatory process.

Boise 11th Street found the technology is "only scratching the surface" (Respondent A). They went on to discuss gaming technology where interactivity, navigating the virtual environment, and providing extra information, is simpler than the current creation process. Similarly, *Seattle HoloLens* mentioned game engines as a requisite for the future of AR/VR creation. Respondent H argued there are many limitations to the current system of creating a virtual environment. Their method was tedious and time consuming. Game engines were brought up as a much-needed improvement, since they are designed to easily accommodate virtual environments. Respondent A from *Boise 11th Street* explained the benefits of a game engine:

> "There's lots of ideas and it's all stems around gaming technology, game engines. You can put a person in a specified location so they can view 360º but literally walk and navigate a project, click on objects that provide information about it, such as the cost to include a sidewalk. It's only going to get better and easier and we're going to see more and more of it."

4.2.6 Other Challenges

Similar to the *Benefits*, this section will discuss case specific challenges. This section will cover a challenge found from *Boise 11th Street*.

4.2.6.1 Education on AR/VR

Respondents from *Boise 11th Street* found governments lacked understanding and education on AR/VR technology. This lack of knowledge was on the cost of the technology and how it can fit within the government's participatory values. From a technical standpoint, Respondent A argued that governments require education on beneficial technology. They found governments do not understand how AR/VR visualisation are made:

> "There needs to be a lot of education within governments and project managers. For me, I'm dealing with CAD 3D modeling software and rendering tools, so to create a VR or an AR is doesn't have to be too much effort. The CAD network is all being reused, and a lot of people don't realise that. I get a lot of questions like 'well is it going to be more expensive?', well not really. Just from the standpoint of the technical side, there's still a lot of educating to be done." Respondent A.

Respondent B detailed this challenge and how it affects a government's judgement on the technology's value. They argued that the government's understanding has caused them to overlook the technology for other methods, not knowing the cost of AR/VR would be the same. It is not simply about understanding the actual cost, which might be less expensive than governments realise, but "it's judging how it fits in terms of the value it returns for the budget they [governments] have". They talked about how governments would rather adopt something which has been tested and tried, rather than something new. With a greater understanding of what AR/VR offers, they argued more governments would be willing to try it.

Chapter 5
Discussion

This discussion contains the results presented in the previous chapter. It will discuss findings and themes from the comparative case study while drawing parallels to literature, with the intent on understanding AR/VR in a participation setting. Having examined the results of the five cases, it is determined that the technology's viability as a participatory tool is heavily dependent and reliant on certain factors, from costs, to the content of the visualisations. To examine the research objective and question of this study further, this chapter divides the discussion by its defining ability as an urban planning tool, its viability in citizen participation, the required growth for it to succeed, and the research limitations.

5.1 An Urban Planning Tool

Lynch (1960) described the spatial relationship citizens build of their surroundings. Based on landmarks and visual cues, citizens establish a mental map of what they deem important. Visualisations of the built environment in project plans and proposals, try to simulate the landmarks and cues citizens create. However, citizens can struggle in attempting to connect a visualisation to the real-world. AR/VR visuals try to be as realistic to the environment as possible, so citizens can understand the 3D world they are seeing and connect their spatial cues to the virtual environment. Al-Kodmany (1999) argued that 2D visualisations have been unsuccessful in providing context on project plans. For 3D visuals, he described them as tools for citizens to experience the project before anything is built, which aids in distributing project information. What is not mentioned is the complexity of urban planning projects, from the plans themselves, to planning phenomena and terminology. Urban planning and citizen participation has increasingly tried to become open to everyone, and not cater to the select few who grasp the complex nature of the process (Day, 1997; Innes & Booher, 2004). AR/VR technology can facilitate this change by informing citizens of project proposals, by providing them a tool that aids with visualising context through realism and helps in transferring knowledge between citizen and planner.

AR/VR technology is seamlessly placed into an area where it functions exceptionally well as an urban planning tool. Respondents from this study mentioned the impact AR/VR had on citizens who struggled with understanding urban planning language and project details. There was agreement that the technology disseminates complex information in an easy-to-understand visualisation, which was realistic to the point where citizens could grasp and conceptualise the project. The reasoning is placed heavily on the visuals in the virtual environment. Herbert and Chen (2015) described 3D visuals as more useful in making citizens familiar with the project plans, compared to their 2D counterparts. In the case of *Seattle HoloLens*, citizens struggled grasping, through written plans, how setback and height bylaw changes would affect their neighbourhood. Once wearing the AR device, they understood the changes which would take place. It was found that AR had the ability to visualise abstract conversations in a meaningful and simpler way that resonated with citizens.

5.1.1 Realism

3D visualisations and AR/VR experiences use realism within the virtual environment. Realism in AR/VR is debated in literature regarding its purpose and usefulness (Al-Kodmany, 2001b; Gill & Lange, 2015; Heldal, 2007; Herbert & Chen, 2015; Kuliga et al., 2015). Lange (2005) believes that realism is important but not necessary for citizens to connect the visualisation with project details. Al-Kodmany (2002) found a lack of realism affected citizen's evaluation of a development's aesthetics, meaning realism was necessary for citizens to understand the project. However, realism can produce a sense of false-truths, where the rendering exaggerates, lies, and distorts the reality of the project (Obermeyer, 1998). The results of this study found multiple defining factors of realism's usefulness in AR/VR visualisations. As an urban planning tool, realism is essential for citizens to ground themselves in the virtual environment by connecting the visualisation to reality. Further, the accuracy of 3D models portrays certain truths. These findings contradict research which states realism is unimportant or not necessary. Similarly to Obermeyer (1998), there are concerns surrounding the idea of overexaggerating the visualisation to the point where it is different than the final product.

Stahre et al.'s (2013) literature review on challenges facing visualisations showed a disagreement in research on the topic of realism. From this research, findings convey the importance realism has on urban planning AR/VR visualisations. Heldal (2007) saw that realistic contextual information in their VR visualisation allowed citizens to better grasp and understand the proposed plan and changes. Gill and Lange (2015) found realism affected the citizen's understanding of the project details. Drettakis et al. (2021) acknowledged the importance of realism in urban planning visualisations because they are used to present, propose, and review contextual information of a project. In this study, realism made it possible for citizens to connect the AR/VR visualisation to their environment. Citizens create relationships with their built environment, calling them cues that ground them in reality once placed in a virtual environment. Having these virtual cues connected the citizen to the visualisation. This allowed citizens to easily obtain information, project context, and conceptualise the project. Further, citizens became more educated on planning principles and phenomena since a transferring of knowledge was able to occur between citizen and planner.

It was made evident that missing realism affected the citizen's understanding of a project and disconnected them from the virtual environment. AR/VR has a requirement other 3D visualisation do not have, which is to create an extent that goes beyond the horizon, to have an entire 360˚ view. Using this technology requires an environment far more complex than other visual formats. If elements are missing, such only having a 180˚ environment which does not have background content, a static image of items floating in midair (*Seattle HoloLens*), or the environment ending abruptly, it displaces the user. Once the citizen sees that realism is missing, they lose their relationship with environmental cues. *Seattle HoloLens*' virtual environment was a static image which had a skateboard floating in midair. Not only is this unrealistic, but it caused citizens to become less interested in the visualisation and unsure of the accuracies of the renderings. This finding counters Stahre et al.'s (2013) statement that the abstraction and complexities in realism overloads and confuses the user. Rather, this research found a low level of realism confuses the citizen, displacing them from the experience, meaning a realistic interpretation of reality is a requirement for AR/VR.

Realism is not only having textures on facades, correct lighting, trees, bushes, people, benches, etc., in a scene, it also includes the accuracy of 3D models. Al-Kodmany (2001b) described 3D models as accurate representations of reality. This interpretation of accuracy refers to 3D models created by computer software. Software such as AutoCAD, SketchUp, Rivet, have the capability of model creation with perfect measurements built to scale. The immersion of AR/VR better depicts the accuracies of these 3D models. *Boise 11th Street* expressed the renderings as having geometric accuracies. The renderings reinforce the importance of realism for showing citizens precise details of the proposed project. To a certain extent, it creates a truth in the visualisation, meaning a building, sidewalk, or street, would be accurate to how it would be in the real-world.

This study reaffirms realism is essential when creating a 3D virtual environment for AR/VR. This contradicts research by Herbert and Chen (2015), Lange (2006), and certain aspects of Stahre et al.'s (2013) literature review. Herbert and Chen (2015) found urban planners did not require realism in the virtual environments as they were able to connect the visualisation to their spatial surroundings. The issue with this statement is that citizens are not planners, some individuals struggle with understanding spatial experiences. Lange (2005) argued that not every case must have realistic visualisation, rather it is dependent on what is being presented. Stahre et al.'s (2013) literature review mentioned that too much realism would be counterproductive, by making the visualisation confusing with the inclusion of abstraction and parameters. However, this case study identifies the significance of including accurate realism to AR/VR visualisations. When AR/VR is an urban planning, conversation creating, or disseminating of information tool, it requires a level of realism. The crucial goal of urban planning visualisations is to present and review the concepts of what are being proposed (Drettakis et al., 2021). Once there is a lack of complexity, this research found citizens struggled understanding and connecting themselves to the space. This study agrees that realism is integral if it is used as an urban planning or participatory tool.

5.1.2 The Truths in AR/VR

Obermeyer (1998) and Al-Kodmany (2002) expressed concern relating to the truths of 3D visualisations. It is based on the premise that those behind the creation of the visuals can alter and exaggerate the final product to be far from reality, to show what they believe is the correct vision for the project. Al-Kodmany (2002) called this a danger, audiences can be given a visual that is the furthest from reality, but is accepted as the truth based on its realism. With the immersion possible from AR/VR technology, there is higher risk of accepting these false realities. AR/VR were considered fantasy by *Boise 11th Street*, where they could use realism to make them feel genuine. Further, the creator of the visualisation is in complete control of what the citizen sees and the final presentation of the project. *Reimagine Robinson Street* and *Boise 11th Street* asserted that the creator is in control of the entire experience. The threat of lying in the visualisation causes skepticism and can further citizen distrust in governments and politics. Photoshopping the real-world to be more artistically pleasing and creating a final product nothing like the rendering, is the cause for concern in adopting AR/VR as an urban planning tool. Heldal (2007) mentioned that VR can easily mislead citizens in misunderstanding the visualisation. This prompted a participant to argue that the environment must be representative of reality. There is a tight margin for AR/VR visualisations, they cannot overpromise or underdeliver, and must be expressed between this fine line. Communication is essential between government, citizen, and the visualisation creator.

5.1.3 Urban Planning Complexities

Urban planning is full of complexities that even planners themselves struggle in defining. Citizens who want to be involved in the planning process, the terminology, phenomena, and trends can be difficult to grasp when they have a high level of complexity. Urban planning has had a tumultuous past, where planners were experts in the process, using intricate language to control citizens in decision-making (Davidoff, 1965; Day, 1997). As we move forward, complexities will always exist that are difficult to understand. Visualisations are created to express these complexities, as they are easy-to-understand and simple to connect with. AR/VR has the capacity of knowledge creation through transferring information. This ability occurs by simplifying and disseminating project details to citizens. Details cater to engineers and planners, such as CAD models, ancillary benefits of policy change, and views of road diets. These complex terminologies are understood by planners, but citizens can struggle grasping what they mean. They require a visualisation which accommodates their level of understanding towards the spatial environment. Lacking spatial awareness is an issue for many citizens. Visualising written plans is difficulties in understanding how it will affect their neighbourhood. Considering many plans include complex language, AR/VR provides them the understanding they require.

Innes and Boher (2004) determined that urban planning has failed citizens, that it requires change to move away from decades of tokenism in decision-making. While this change is still ongoing, AR/VR provides context of the built environment to less active and younger citizens. For these citizens, AR/VR visualises the smallest adjustment to public policy that can have the greatest impact on their lives. *Seattle HoloLens* used AR to show bylaw amendments for the heights of buildings, something which seems minute, but was done to increase the availability of affordable housing. Through the AR experience, citizens grasped the proposal, making the project feel real and personal. Participants in Heldal’s (2007) research mentioned VR was equipped to visualise height changes, which produced a better overall understanding of the project. *Lethbridge ELUS and SASP* used VR to envision how density alterations to the bylaws would look in the future. It allowed citizens to understand the impacts of these change and what it would mean to the neighbourhood they live in. Further, AR/VR has attractive characteristics to younger generations who might be uninterested in planning processes. Incorporating AR/VR can allure them into civic governance, making for a more diverse and open process in the future.

The ability of AR/VR as an urban planning tool is not only subjected to helping citizens, but decision-makers as well. Decision-makers are still citizens, they simply hold a professional position in a political process. Even with a working knowledge on urban planning, complexities still arise which some decision-makers find difficult. Further, decision-makers are meant to be non-biased, however, they do harbor their own opinions (*Boise 11th Street*). To make the best decision possible, AR/VR can present how their decision can impact their constituents, by enabling different scenarios of the proposal, showing the full story of the project.

5.1.4 Diffusing Controversies

When a government proposes a project, controversies arise regarding its cost, benefit, NIMBY, future, affect on the area, etc. AR/VR is characterised as a planning tool that provides a clear and understandable visualisation to citizens, dispelling certain disagreements. *Seattle HoloLens* found citizens were drawn to the participatory meetings due to controversial elements of the proposal. Since AR/VR excels in educating the user, citizens driven to the meetings by controversies left the meetings with a better understanding of the exact nature of the recommendations. It communicated the truths of the project and dispelled myths that circulated in the community.

From a government's perspective, it spurs conversations regarding the project, earlier and more effectively, than other visualisations. AR/VR has the capability of showing different project scenarios which aids in demystifying controversial characteristics. Further, addressing these controversies early in the process, rather than at the time of development, is beneficial in keeping citizens pleased with the entire process. AR/VR can be used as a proactive tool that disseminates information, to show all scenarios and possibilities of the project, which generates discussions on what should be kept, altered, or scrapped. AR/VR goes beyond visualising change. It effectively communicates project scenarios earlier in the development process, making it useful in addressing the greatest outcome that is supported by citizen discussions.

Despite issues regarding the truthfulness in renderings, AR/VR is well suited to aid, educate, provide clear details and context, connect the user to the real-world, and proactively communicate project scenarios. Since these are robust opportunities possible from using AR/VR visualisations, it shows the effectiveness and capabilities of the technology as an urban planning tool. Being identified as an urban planning tool means, when adopted, it successfully helps citizens visualise complexities and change to their urban environment. Drettakis et al. (2021) stated urban planning visualisations are meant to provide context and review information for citizens. This study finds AR/VR has those exact characteristics, by providing a conceptualisation of a project, context in a visual format that is easy-to-understand, immersive, realistic, and educative visualisation. AR/VR is not only realistic, but fun, experiential, and proactive, making it unique compared to other visualisations. While recognising there are concerns surrounding the dangers of lying or overexaggerating the project in the virtual environment, this can be alleviated through direct communication between government, citizen, and creator. Further, scenes or multiple scenarios can be created, showing alternatives, allowing citizens to visualise a range of options, and spur conversations.

5.2 Viability for Citizen Participation

Citizen participation is incorporating citizens into decision-making, by using their local knowledge in advancing fairness and justice (Innes & Booher, 2004). Determining incorporation is defined by the models, mechanisms, and tools used within that system. Understanding the viability of AR/VR as a participatory tool is an analysis of this incorporation. This study pursues the call for research on government's implementation of technology in citizen participation, and how it enables or limits participation (Berger et al., 2016; Janssen & Zuiderwijk, 2014; Johnson et al., 2019; Rowe & Frewer, 2005). Further, Rowe and Frewer (2005) argued technology profoundly changes mechanisms in the participatory process. In addressing these concerns, this section establishes the role AR/VR has in citizen participation. When possible, this section compares findings from the comparative case study with existing research. Due to the gap in research on participatory AR/VR, certain results are new and unable to be examined alongside current literature. This section concludes that, in AR/VR's current state, it is unviable as a participatory tool. It must follow a strict path, deviating or being adopted incorrectly causes participatory issues.

To understand AR/VR's viability within citizen participation, considerations are made on all factors integral to its adoption. From a participatory standpoint, it was found AR/VR engaged citizens with the project, is compatible with online systems, has a uniqueness of immersing the user on site of the project, and can be implemented in a co-production model of participation. However, this study found AR/VR barely impacted feedback, with no differences between traditional techniques and AR/VR, is incapable of working as a standalone format, the isolating nature withdraws the citizen from the participatory process, citizens focus heavily on the experience and less on the content, and finally, a strict format must be used when adopted, otherwise it limits the technology's capabilities.

Considering beneficial factors outside of participatory settings, it attracts younger citizens because of its technological nature, and educates citizens on urban planning and technical terms. Constraints of cost and time are factors which decide if it succeeds or fails, the niche and novelty of AR/VR limits the private sector and is seen as a gimmicky tool to their constituents, and the virtual environment can lead to false-truths of overselling the final product. There are many influences to consider in determining the technology's viability, therefore, this section is divided into two segments: characteristics which can make AR/VR successful, and shortcomings which undermine AR/VRs capabilities in citizen participation.

5.2.1 The Characteristics of Success

5.2.1.1 Citizen Co-produced Renderings

Citizen co-produced renderings is described as citizen contributions being built into a virtual environment. Van Leeuwen et al. (2018) named this process co-design, and has similarities to the co-production process outlined by many researchers as the pinnacle of success in citizen participation (Horne & Shirley, 2009; Linders, 2012; Rosen & Painter, 2019). This co-producing of a virtual environment takes direct citizen contributions of a proposal and builds a rendering which represents their contributions. It is possible to complete this real-time, where an AR/VR specialist takes feedback and produces a virtual experience within a workshop setting. Further, it can be completed after a period of participation meetings, where citizen feedback which is culminated into a rendering.

Co-produced renderings is based on the model of co-production expressed by Linders (2012). Under this term, Horne and Shirley (2009) expressed that citizens contribute "time, expertise, and effort" to achieve "an outcome, share more responsibility, and manage more risk in return for much greater control over resources and decisions." The IAP2 code of ethics refers to anyone impacted by a project has the right to be apart of the decision-making process. With participatory AR/VR, this can become a reality if using a co-produced space of citizen participation. In the discussion on the *Truths in AR/VR* section, the issue presented was the creator distorting the "truth" of a rendering. Having a space where AR/VR renderings are built using citizen feedback in a co-production model, opens transparency, places the citizen in a greater role concerning decision-making, and produces a rendering true to reality.

5.2.1.2 Age

Younger citizens are occasionally less inclined to participate in political processes (Henn & Foard, 2012). This inclination trickles into participation processes, as younger people are uninterested or feel their voices are unheard in decision-making. This is reasoned by a distrust in institutionalised governance causing political frustration (Henn & Foard, 2012; Henn & Weinstein, 2006). Participatory AR/VR appeals to younger audiences, mainly due to its technological nature. Many younger citizens have already experienced an AR/VR type of visualisation, either in video games or smartphone applications. Their understanding of the technology, and the fun experience of AR/VR, demonstrates a tool that has technological attraction that benefits younger generations. Further, the learning curve required to operate the devices becomes less of a challenge, they see more value in adopting technology for participatory processes, and become less reactionary towards it. Since this technology is understood by younger generations, its novelty will be less impactful, meaning they will focus more on the content of the visualisation. Banaji and Buckingham (2010) argued for more research on finding ways to engage broader audiences in citizen participation. From this study, AR/VR is found to be engaging and beneficial to younger generations.

5.2.1.3 Trust and Novelty

Participatory AR/VR has potential to improve citizen-government relationships. Mentioned in the *Age* characteristic is a distrust amongst citizens and their government. Citizens believe their voices are unheard and governments apply a minimum effort in fielding their concerns. Employing participatory AR/VR aids citizen-government relations by being novel. Adopting this technology shows a willingness by governments in trying a new technology to citizens, which builds trust between citizen and government. While a participatory process is common legislature in North America, the level at which it is carried out varies. Some cities have strict guidelines, while others do a bare minimum. Adopting a new technique that most constituents have never tried, can build much needed relationships. *Seattle HoloLens* described adopting AR/VR as being more open to trying new ways to engage their constituents.

Novelty of AR/VR relates to the quality of it being new and original. To many citizens, they might know AR/VR technology, but have never been experienced it. Respondent C claimed that the participatory process can be mundane, boring, and unimaginative. It requires something new and exciting to bring meetings and feedback to another level. It was argued that AR/VR has this capability. *Lethbridge ELUS and SASP* discussed excitement in their participatory process when using AR/VR, something which was missing from previous projects. Generally, most cases from this study adopted AR/VR because it was new, fun, exciting, and intriguing. However, novelty is just that, it is something new that brings excitement to the decision-making process but struggles in changing such a process. The excitement did lead to a creation of trust between citizen and government, and that the willingness to adopt it further shows a level of improvement in decision-making.

5.2.1.4 Immersion and Realism

Immersion and realism were found to benefit citizens by allowing them to spatially connect the visualisation to the real-world, and take in more complex information. A citizen is placed into a virtual environment by the wearing a device or using a smartphone, and is immediately viewing an interactive version of reality. This level of immersion, alongside its realistic nature, allows citizens to better understand the project, which leads to a potential benefit of more accurate and thorough feedback. The similar topic of realism was discussed in the U*rban Planning Tool* section, therefore, this will be cover participatory benefits found from the comparative case study.

Al-Kodmany (1999) described 2D visualisations as a failure in citizen participation. He argued that traditional planning tools (photographs, paper plans, maps, etc.), failed to engage citizens and facilitate participation. In later research (2001b, p. 14), he found 3D visualisations "were illustrative and engaging, necessary ingredients for public participation". When placing the 3D visualisation into a VR environment, he argued that immersion can "communicate the experiential nature of urban settings" (2001b, p.15). *Lethbridge ELUS and SASP, Boise 11^th^ Street,* and *Reimagine Robinson Street* believed using AR/VR was more than looking at a visualisation, it was about an experience of feeling, seeing, sensing, and communicating a project. They compared this feeling to traditional visuals, where Respondent E contrasted VR to a 2D map, stating that in VR, citizens feel as if they are placed in the environment after the project is completed, something 2D maps are incapable of portraying. Similarly, Respondent I found that photographs and maps only show a small extent of the project. Instead of a citizen trying to spatially visualise the project through multiple photographs, they can be immersed into a visualisation which has built the spatial framework for them. Further, for AR/VR to be immersive, the visualisation must be realistic. This study found realism is integral for citizens to produce spatial connections. With this connection, there is potential for citizens to produce more detailed and grounded contributions. Realism allows citizens to obtain information through a realistic depiction of reality, making it a trait that other participatory visuals and techniques lack. With AR/VR, it has a unique ability of being placed on site of the project. This is possible using mobile units, such as the expensive headset devices of Oculus or HoloLens, or smartphones. The benefit of having mobile units is the mobility of it working anywhere. Before wearing the AR/VR headset, the citizen can look around the site and see what already exists, then be virtually immersed into what the project is proposing. Having this level of on-site participation allows citizens a better understanding of how the project will affect the current space.

5.2.1.5 At-home and Online Participation

Online participation is an important aspect of many modern projects. Using the internet as a tool to garner feedback, present project details and disseminate information, are options for many governments (Evans-Cowley & Hollander, 2010; Kingston, 2011). In the context of AR/VR, it allows citizens unable to attend in-person meetings to view the content online. As AR/VR is an entirely computer-based visualisation, cities can upload the renderings and 3D virtual environments directly to an online platform for anyone to view. *NRVR* described their online platform as a space where citizens were comfortable participating. This case study found citizens were self-conscious using the devices in-person. Not every citizen is prepared to participate in-person, making at-home and online participation a beneficial method. If a meeting becomes hostile, there are citizens who would be less likely to provide their opinions. Online participation would allow those citizens a safe space to present their views.

Reimagine Robinson Street and *Boise 11th Street* decided on the webhosting service IRIS VR, mainly due to its ability to upload 360˚ environments viewable from a smartphone application or computer. *Lethbridge ELUS and SASP*'s virtual environment was a 360˚ video, therefore they decided the best platform was YouTube. The video was linked on the Lethbridge's website which had surveys and questionnaires citizens could complete. *NRVR's* platform had details on the projects, before and after photographs of the projects, and a feedback survey system. Since this case worked through the COVID-19 pandemic and all in-person activities were delayed, creating an online platform with this amount of detail was required. What gave these cases the possibility of having an online participatory system was the characteristic that AR/VR is entirely computer-based.

5.2.1.6 Compatibility

The virtual environment in AR/VR is entirely made of 3D models. Many city departments have existing models and data that can be easily translated into an AR/VR experience. Further, city planners, engineers and architects are familiar with 3D data. Since AR/VR environments are entirely 3D, the space in which they function benefits most aspects of city planning. With existing GIS data, anything that has an elevation element can be brought into the environment. Additionally, online repositories have endless amounts of data, textures, and 3D files, which are easy to download and are compatible with most 3D software. Planning departments in cities often use GIS software or spatial data. ESRI has partnered with Unreal Engine, who developed VR software that takes 3D GIS data and builds a virtual experience. The level of compatibility from government data to an AR/VR visualisation shows a successful capability of this technology. Since there are many possibilities of using existing data and online repositories, the compatibility of this tool allows the reuse of existing data, which reduces the cost and time of creating a rendering.

5.2.2 The Shortcomings

5.2.2.1 Isolation

Al-Kodmany (2002) argued VR visualisations take a citizen out of the face-to-face grounded dialogue that is intrinsically apart of citizen participation meetings. This form of communication is essential for quality feedback and the formation of social capital (Arnstein, 1969). The issue with VR, as described by Al-Kodmany (2002), is its isolation. While AR devices are not known to be isolating, *Seattle HoloLens* used HoloLens, which is different than typical AR. Like VR, the device goes over the user's head and isolate them from the meeting. Isolation encounters two problems in adopting AR/VR in a participatory process: citizens lack communication between themselves and officials, losing an important aspect of participatory meetings, and answering questions and understanding citizen feedback becomes difficult.

Participatory meetings are meant to engage citizens with project visualisations and information. In this settings, citizens converse amongst themselves, and other stakeholders, discussing what they like or dislike regarding the proposal. This form of group dialogue generates discussions and interactions which can lead to better cooperation and civic solutions (Arnstein, 1969; Callahan, 2007; Fung, 2006). With traditional participatory techniques, citizens are placed in an open forum where they can physically see and converse with everyone. When AR/VR is adopted, this open forum becomes closed to the individual wearing the device. Further, the individualistic and isolating aspects of AR/VR determines that it cannot facilitate group discussions. Thus, the format of feedback becomes limited to individual methods, such as a survey or questionnaire, which have been described by Rowe and Frewer (2005) as having little influence on decision-making. This study confirms that isolation and individual experiences make adopting this participatory technique challenging. *Boise 11th Street* and *Seattle HoloLens* were vocal on this issue, describing communication amongst citizens and city officials as difficult. *Seattle HoloLens* argued HoloLens was unviable as a participatory tool, stating the individuality of the experience as being too impactful on communication, making citizens less inclined to discuss their ideas. They described feedback was drawn out of citizens, instead of them willingly providing their own ideas.

When a citizen is in an AR/VR environment, the individual nature of the device makes it difficult to understand what they are describing. When providing feedback, they must describe their opinions with an exaggerated level of details, otherwise city officials and other participants will have difficulty understanding. Challenges arise when a citizen provides feedback that confuses the city official, since they have no perception of what is being described. Further, questions asked by the officials or citizens during an experience are more difficult to answer and convey. Of the five cases in this study, *Lethbridge ELUS and SASP* were the sole project to show what the viewer was seeing to other participants via a projector. This method of adoption alleviates issues regarding the confusing and isolating experience of AR/VR. However, the cases who did not project the user's view found city officials were challenged in understanding what was being described as feedback. When asking questions, officials had difficulty answering since they had no basis of what the citizen was seeing, making communication while in the experience complicated.

5.2.2.2 Engaged with the Visualisation

Traditional formats of visualisations, such as maps and photographs, are catered to citizens being able to physically interact with them. If the government adopts a citizen workshop, citizens interact with the materials, by placing and moving objects. Al-Kodmany (2001b, p. 27) described this as "getting their hands on" with a visual tool. In VR, he found many citizens were not engaging with the visualisation, since there was no method of interaction. More interactivity would engage the citizen in the virtual environment, leading to better feedback quality, since the citizen is focused on what the visualisation is conveying. For many respondents, the future of AR/VR includes a higher level of interactivity, where citizens can move through the environment, interacting with everything around them. In the technology's current state, it limits what is possible. Interactivity would benefit AR/VR for citizen participation, and is something that should be strived for in future scenarios.

Al-Kodmany (2001b, p. 27) mentioned citizens were impressed with the technology, but glossed over the content since they were not "provided the means to design and alter the representation". *Reimagine Robinson Street* expressed citizens would miss the content of the VR visualisation because the technology was overly intriguing. Novelty of VR was found to cause excitement and fun during the participatory process, but impacted citizens when in the experience. Further, novelty caused difficulties in citizens identifying aspects of the visualisation which were for feedback purposes. It was voiced as a challenge in the *Reimagine Robinson Street* project. Many citizens overlooked the content, meaning they were less engaged with the visualisation, but were extremely intrigued and involved with the technology. Missing the purpose and content of the visualisation impacts the citizen's understanding of the project, which affects their feedback.

5.2.2.3 At-home and Online Participation

There are concerns in using AR/VR in an online and at-home setting. Online participation has been regarded as exclusionary towards certain demographics and citizens. Factors of age, language, physical capital, education, and computer literacy are examples of issues (Evans-Cowley & Hollander, 2010; Sieber et al., 2016; Zheng & Schachter, 2017). AR/VR at-home and online requires someone with higher-than-average computer literacy skills which caters to a younger audience, and physical capital to own a computer and the necessary headset devices. Heldal (2007) disseminated their project online for citizens to view, however, they found very few people were able to participate. The reasonings, at the time, were the necessary computer hardware and VR headsets. Van Leeuwan et al.'s (2018) found citizens lacked confidence in understanding the rendering at-home since they had to self-guide themselves through the experience. While there is limited research on online or at-home AR/VR, connections can be made to general online participation research. AR/VR requires devices, computer hardware and literacy, which are components of physical capital and age. The technology accommodates a select few, rather than most of the population.

This study found online and at-home AR/VR participation is constrained by the necessary equipment to operate an AR/VR experience. This includes the headset devices, smartphones, and computer hardware. Further, citizens became less inclined to participate at-home because the experience was self-guided, and they lacked confidence in using the technology. *Boise 11th Street* explained VR devices restrict who can use them at-home, and participate in the full experience. Citizens should be able to experience AR/VR as it is meant to be, however, until the devices are cheaper, and the computer requirements are less strict, citizens will be forced away from at-home participation to in-person. *Lethbridge ELUS and SASP* discussed less inclined participation in their at-home portion of their project. Citizens had trouble accessing the videos, and understanding how to use their phone with a headset. They preferred attending in-person, since a facilitator was there who could explain the technology. At-home, citizens had difficulty identifying what it was they were seeing. Since most participants were from an older generation, they required someone to facilitate their experience. This finding replicate van Leeuwan et al. (2018), where online VR generates difficulties for citizens who struggle understanding the technology and visualisation, making them less inclined to participate.

5.2.2.4 Cost, Time, and Planning

The cost and time to make an AR/VR visualisation is heavily constraining. Several authors emphasised the cost of AR/VR restrains access to the technology (Al-Kodmany, 2001b; Heldal, 2007; van Leeuwen et al., 2018). It has been argued that cost must be alleviated for it to become adoptable (Al-Kodmany, 2001b). Further, governments are heavily constrained by their budgets. When discussing if they can support the technology, their resources will be questioned. While the expensive nature of AR/VR has dropped considerably over the past decade, cost still hinders its development. Heldal (2007) mentioned a significant challenge was the expenses related to VR, however, they understood that this was a start-up cost, where purchasing models and a virtual environment could be reused for future projects. Respondents agreed with this statement, where the initial cost is expensive, but is reduced once the city has the means and resources available.

From this comparative case study, cost was the most apparent challenge facing participatory AR/VR. *Lethbridge ELUS and SASP* discussed cost as a barrier. It barred the quality of the rendering and time it took to be created. As a risk-adverse community, they said using a participatory technique with a high price-tag makes them look past it as an option. Further, the compatibility of AR/VR allows governments to reuse existing 3D data, however, since they are a small city, this data does not exist.

For them, creating, dissemination, storing, and maintain 3D data is too costly. *Boise 11th Street, Seattle HoloLens,* and *Reimagine Robinson Street* expressed cost as a main concern of AR/VR. *Seattle HoloLens* found that the HoloLens technology, which is more costly than other devices, was overpriced to make using it worthwhile. *Boise 11th Street* and *Reimagine Robinson Street* mentioned cost can constrain government's budgets, which force them to overlook AR/VRs potential benefits and find other cheaper alternatives. Similarly to Heldal (2007) start-up costs, *NRVR* was creating a process more so than a single use participatory experience. Their $16 million budget reflects this, as they are trying to create an open-sourced process where cities can use their work to build AR/VR environments, removing the necessary start-up costs.

Time and planning are similar constraints to cost. The longer it takes to produce a visualisation, the more planning is involved. Respondents mentioned time and planning as a prerequisite for the proper implementation of the technology. Respondent F from *Seattle HoloLens* found that working with AR was cantankerous, where each detail in the rendering required extensive planning and manipulating to be perfect. Further, planning was expressed as a "make or break" stage of adopting AR/VR, where the workflow process must be understood, otherwise mistakes will be rampant. Respondent G explained mistakes in the process as a first-time problem, where insufficient planning and lack of understanding of AR caused setbacks. Similarly, Heldal (2007) found the process of generating a VR rendering was difficult the first time due to the technology's novelty. Participatory AR/VR, compared to other techniques, requires a high amount of planning. This increase in time can worry governments. With proper planning, it increases the duration of the project, but can reduce unforeseen costs. If there is insufficient planning, last minute alterations will be costly, and the quality of the rendering will be subpar. There is a distinct amount of planning and money required to have a fully functioning participatory AR/VR tool, which might deter governments from adopting the technology. It also creates difficulty in addressing its viability in citizen participation.

5.2.2.5 Niche and Novelty

Being a niche participatory tool means AR/VR is challenged by the limited number of people can work with the technology. The private sector of AR/VR has focused on certain fields, such as video games, education, and military training, and has overlooked participatory and urban planning process. This has created a niche where AR/VR functions with relative challenges.

With the niche and novelty of AR/VR, the apparent issue is the private sector, where a limited number of companies can create an AR/VR visualisation that is intended for participatory purposes. If a government department has the time, money, and resources to create an AR/VR visualisation, this would alleviate any challenges of finding a consulting company. However, as mentioned, few people can create this format of visualisation, let alone for citizen participation. This study found a private sector causing issues in the quality of the visualisation. *Boise 11th Street* argued that, since AR/VR is a niche tool, most companies will charge exorbitant amounts of money for work that is subpar. With no competition, companies with AR/VR capabilities have exclusivity in the market. With such a small pool of firms and specialised employees, firms face no ramifications in selling subpar work. In effect, this harms the private practice of AR/VR, and steers away governments from adopting the technology.

Since AR/VR is niche, many citizens are unfamiliar with the technology. This study found governments were selling the benefits of AR/VR to their constituents, since many were unsure of the technology's capabilities. *Reimagine Robinson Street* explained that AR/VR technology in urban planning and participation processes are not mainstream, causing it to be seen as a gimmick by governments and citizens. It is argued this gimmick nature makes the technology less desirable. Further, Respondent G expressed the novelty of their experience should not overstate any benefits it had in decision-making. They argued the novelty of the technology was unable to draw more citizens to participatory meetings, and the novelty wore off quickly. Similarly, *Reimagine Robinson Street* stated that offering free pizza was a better tool for engagement than saying VR was technique they were using.

5.2.2.6 Participation and Feedback

Participation and feedback were seen as minorly beneficial when using AR/VR in this comparative case study. In some cases, citizens were more engaged with the AR/VR visualisation and participatory aspects of the meeting since the technology was enjoyable. However, when comparing the participation to traditional techniques, the participation and feedback is similar. Respondents had difficulty expressing differences between feedback produced using AR/VR and techniques they had been using for years. When discussing the actual technology, *Reimagine Robinson Street* expressed AR/VR communicates ideas and projects in a more engaging and interesting way than traditional poster boards, photographs, and maps. Considering this was mentioned, they still found AR/VR was not altering citizen contributions in a better or worse way than traditional methods. Other cases discussed a faster participation setting, where citizens were more excited to volunteer reactions, however, feedback was similar across all techniques. The results showcase AR/VR has characteristics which can potentially allow it to alter contributions to being more detailed and understood. Respondents felt their approach to the technology in its current position limited this possibility. While certain characteristics of the technology are beneficial, it is the aspect of feedback production that is the shortcoming of participatory AR/VR. When no differences can be seen in comparing participatory AR/VR to traditional techniques, it raises the question: should AR/VR be used in participatory processes? It entirely relies on the government's approach to implementing it.

5.2.2.7 Standalone Technique

During the participatory process, it is common to have different techniques to garner feedback. Most meetings will have multiple visualisations of the project, through means of videos, photographs, and maps. Information will be presented through these visualisations and discussions. While it might seem that AR/VR can combine all these visualisations and information into one tool, the comparative case study found it was unable to adequately serve as a multi-purposed technique. *Reimagine Robinson Street* and *Boise 11th Street* expressed that their use of the technology always had to be supplemented by other visuals. They stated that AR/VR was not capable of being a solo technique, rather there was still a reliance on traditional methods of engagement. Not working as a standalone technique is a direct result of the isolation in an AR/VR environment. With this isolation comes a lack of communication and discussions other techniques offer. AR/VR misses the participatory aspect it requires to be viable in citizen participation, which is why it cannot be used by itself. Respondent I believed that AR/VR has the capabilities of a standalone technique but will only come to fruition once the technology adapts to being communicative.

5.2.3 Summary

Viability of participatory AR/VR can be described as its ability to successfully function as a participation technique in a decision-making process. Citizen participation's goal is to incorporate the opinions, thoughts, ideas, and local knowledge of citizens into the basis of a government's decision. To obtain contributions, governments must adopt methods and techniques which elicit feedback. Exploring the respondents' comments, interview data, and in comparison to prior research, participatory AR/VR has characteristics of success, yet are clouded by shortcomings that constrain the technology. Further, the framework implemented by the five cases limited AR/VR's potential in being a participatory technique.

While citizen contributions are generated from using AR/VR, this feedback is similar to comparable techniques. Online and at-home participation is possible, however, it requires computer hardware and virtual peripherals few citizens have. Novelty brings intrigue and engagement but forces citizens to focus on the technology, missing the content of the visualisation. Immersion and realism educate the citizen and provides them a realistic depiction of the project, but issues regarding the truth in renderings could negate the benefit. Isolation of AR/VR forces the citizen out of the important face-to-face discussions in a civic participatory meeting and produces difficulties in providing clear and understandable contributions. There are beneficial factors to its implementation, such as using it in a co-produced space, has attractive traits for younger generations, and builds trust in citizen-government relationships. Governments must identify these benefits and weigh them against the cost and time required for its development. Based upon answering the research question and determined by the results outlined in this section, AR/VR as a participatory tool is unviable.

As a visualisation, AR/VR is undeniably more precise, realistic, and fun compared to its counterparts. It is unfair to say that participatory AR/VR should not be adopted or is completely invalid in citizen participation. It has potential to be successful if properly implemented. However, if the framework for effective adoption is ignored, it becomes a visualisation that educates citizens as an urban planning tool rather than a participatory technique. Therefore, to regard AR/VR as a participatory tool, it must meet certain requirements by following a distinct path. Straining too far from this predetermined direction causes it to lose grasp of its intentions.

5.3 Requirements for Progress

AR/VR is described as reaching a tipping point, where it must pass an imaginary threshold, to see mass adoption and success. The consensus from this case study is that AR/VR must follow certain requirements for it to progress and be viable as a successful participatory technique. Costs, in terms of money, time, and planning are barriers for adoption. Necessary peripherals and creating the virtual environment characterise constraints. AR/VR isolates the citizen from the important face-to-face, group communication of a participatory meeting, an issue more challenging compared to others. For AR/VR to become widely accepted as a participatory tool, it must be interactive while the citizen is in the virtual environment. Thus, there needs to be a form of communication and interaction that happens real-time, which can be within the virtual environment or verbally with a facilitator.

Technology inevitably progresses, which will occur with AR/VR, however, there are concerns that might not change in its development, such as becoming disoriented when wearing a device, the required use headset devices for online and at-home participation, and skeptics of its effectiveness as a participatory tool. Therefore, to progress, AR/VR must adopt a framework which compliments its characteristics. This structure involves a facilitator or guide who directs the citizen through the visualisation, a projection of the citizen's view to others in the meeting, a co-produced space where renderings are designed and built together between citizens and government, and a platform which facilitates each requirement, in reducing the developmental constraints of cost and time.

5.3.1 Isolation and Interactivity

In 2001b, Al-Kodmany stated for VR to operate as a participatory tool, the technology must facilitate interactions real-time. When using the technology, researchers, officials, or facilitators must record emotions, thoughts, and feedback while the citizen is in the experience. This reasoning is established by the isolating nature of AR/VR, which removes the citizen from group discussions. Since the technology is isolating, there is a requirement to replace face-to-face communication. Thus, a facilitator must guide the citizen through the experience, explaining details the citizens is viewing, and asking and answering questions. Cases in this study lacked the guided experience required to provide the best participatory experience to citizens. AR/VR visualisations should be similar for each citizen, where it is guided in the form of a script, otherwise the individual nature of the technology emerges and impacts feedback. Therefore, to progress outside of AR/VR's current state, it requires a framework which involves the citizen more than it currently does, by incorporating real-time questions and information to guide them through the experience. Further, to make the technology into a group-oriented experience, the facilitator or guide can project the citizen's view onto a screen. This allows citizens who have yet to try the technology a view of what to expect, but also the ability to visually connect feedback already provided. It can start the basis of group discussions before entering the experience. Isolation constrains the viability of participatory AR/VR, therefore producing real-time feedback is a requirement. If the citizen is stuck in a period of isolation without a guide, script, or facilitator, the technology reverts to being a valuable urban planning tool.

A secondary point made by Al-Kodmany (2001b) is the technology missing the hands-on nature which gives benefit to traditional techniques. To create the hands-on characteristics means to add interactivity to the AR/VR visualisation. Simply, this is another form of real-time communication that is happening. Rather than with a facilitator, guide, or citizen, it is interacting with the visualisation. This can be formatted as text bubbles, movable objects, the creating and destroying of aspects in the visualisation, or audio. It would not replace dialogue, but it improves the missing hands-on characteristic. This study found, in certain cases, citizens focused more about the technology than the actual content. Thus, including interactions in the virtual environment and outside using a guide or facilitator, would keep citizens focused on the purpose of the visualisation and produce non-isolated feedback, which has potential to be more complete than other participatory techniques.

5.3.2 Constraints of Cost and Time

The constraints of cost and time are important in determining if a government is willing to adopt AR/VR. Money is required to build the visualisation, run it with computer hardware, and purchase the necessary peripherals to use AR/VR in its fullest extent (Al-Kodmany, 2001b; Heldal, 2007; van Leeuwen et al., 2018). With an exorbitant cost and strict project budgets, AR/VR finds itself in a difficult area for adoption. There must be commitment on the side of the government to implement it. As found from this comparative case study, cost is still a barrier. If AR/VR costs are to be reduced, the private sector must expand, however, for this to be possible, there must be demand. Further, it was found the private sector impacted the product being made. The sector has high costs for a subpar visualisation, a small pool of consulting firms capable of producing an AR/VR visual for participatory processes, and few experts exist in participatory AR/VR. This results in firms having control over the sector and negatively impacting its adoption.

Other costs, such as the price of computer hardware and the required visualisation devices, must change. Currently, the computer hardware necessary to run a full VR experience are obtainable in cost, but not to everyone. If at-home participation is a component of the participation process, it will not be possible for citizens to have the necessary components to run an AR/VR visualisation in the immediate future. Luckily, most citizens own a smartphone with hardware capable of experiencing the tool. Unfortunately, there will always be a requirement of a headset device. Thus, progress will be possible through the availability of newer and less expensive devices, or mass adoption of experiences through smartphones.

To adopt AR/VR, there must be a decision on what format of technique is applied. Using a smartphone allows the citizen to use their own device, is much cheaper, and permits citizens to participate at home, but lacks full immersion and interactivity. If immersion and the full experience of interaction is the reasoning for its implementation, then the option is using a headset device with necessary computer hardware, however, this is expensive and limits who can participate. Technological progress in AR/VR is yet to reach its potential. Prices of hardware and peripherals have dropped dramatically in recent years and are trending downwards. The concern for the technology's progress is understanding there is a variety of technologies to consider for implementation, each with different benefits and challenges.

Cost also involves time and planning. These constraints relate to the complexity of building AR/VR for participation. Comparatively to other participation techniques, planning months in advance is mandatory, otherwise it will increase expenses, reduce the quality of the visuals, and negatively impact the citizen's experience. Further, building the virtual environment takes time and resources. Conventional visualisations show the immediate extent of the project, whereas AR/VR must have a 360˚ environment. Creating such an extensive virtual environment requires the creator to go beyond the typical extent, including a horizon, periphery, and models in the background. Building this format of virtual environment with no previous 3D models, requires months of planning. However, software capabilities, especially in game engines, makes this planning process shorter, less time consuming, cheaper, and includes elements which make the virtual environment more realistic and interactive than alternatives. Thus, creating an AR/VR visualisation in a game engine or predefined environment (open-sourced process) is a necessity moving forward.

5.3.3 Citizen Co-production

The bi-directional structure of co-production in the design stage of this tool allows for greater transparency in the project development. The traditional model of creation is entirely based on the government's vision, along with the firm's abilities (Al-Kodmany, 2001b). Not only can this lead to false-truths, but it is a continuation of top-down decision-making. Co-production of AR/VR renderings makes it possible for citizens to have a greater role in decision-making, by having their feedback, concerns, ideas, and expertise (Horne & Shirley, 2009), be made into a visualisation. In this case study, adopting AR/VR was found to impact trust in two ways. Constituents gained faith that their government was trying to improve citizen participation by implementing a novel technology. Secondly, governments are in control of the design phase of the rendering, leading to possible misrepresentations and deceptions regarding the project. Having co-produced renderings establishes greater trust in government-citizen relationships. Further, it produces a truthful visualisation that will not overstate or lie on project deliverables. Moving forward and progressing in AR/VR, requires a state of co-production. Similarly, this can be said for most models of citizen participation, smart cities, and open data (Johnson et al., 2015; Linders, 2012; Zuiderwijk et al., 2012). There is a necessity to move on from hierarchical participation, to have a space where citizens obtain greater control over decisions which affect them.

In a participatory process, co-production of AR/VR is easily producible under the structure of using a pre-existing modifiable virtual environment. A facilitator can create and modify a rendering real-time during a participation meeting, or over-time after a feedback process has taken place. To achieve co-produced AR/VR, it involves the deciding of tools, creating or updating 3D models, and someone capable of working in a virtual environment (van Leeuwen et al., 2018). Respondents in this case study discussed the desire to repeat their project in a co-produced and real-time feedback space. They understood citizens co-producing AR/VR visualisations benefits everyone involved in decision-making. The desire to rework their projects in a format which better suits AR/VR, and research identifying the importance of citizen co-production, recognises this model as a requirement moving forward.

5.3.4 Game Engines

The requirements for progress emphasise the importance of certain criteria to shift the viability of AR/VR in citizen participation. The technology has characteristics of success, but needs to act upon its qualities to become viable. To support the criteria, a platform is required that provides real-time feedback through a guided experience, reduce costs and time in building the virtual environment, and adopt co-produced renderings. Game engines are the platform participatory AR/VR requires.

Real-time interactions, realism, and ease of creating an AR/VR visualisation in a less costly and timely manner, constrains governments for its adoption. When items cost more to be included in the virtual environment, budget restricted governments are forced to look for other forms of visualisations and tools. In a game engine, the requirements for progress come easily, as it has a predetermined virtual environment. Further, these engines are compatible with GIS and 3D data, and have an intuitive user interface and experience. When working from the engine, the facilitator can modify, add, and replace items in the virtual environment real-time and produce an AR/VR experience in the duration of a participatory meeting. The predefined virtual world of game engines makes the co-production of renderings more plausible and adoptable than before. The virtual environment of an engine, with the inclusion of realism, virtual and real-time interactivity, and a space where co-production flourishes, creates the ideal scenario for participatory AR/VR.

5.3.5 Open-sourced Process

From the results and subsequent discussion, participatory AR/VR has been depicted as costly and time consuming. Hence, considering an open-sourced process would benefit other governments and citizens by having access to a successfully implemented project. *NRVR* described their goal was to create a platform other governments can adopt. If successful, this open-sourced concept can expose smaller and budget-restricted governments to the idea of using participatory AR/VR. It would alleviate the required start-up costs and provide municipalities the tools to successfully implement a viable technique in their participatory process. Further, an open-sourced platform can create partnerships between governments, improving the process after each iteration.

5.4 Methodological Limitations

A methodological limitation of this study is the small sample size of participants. In this comparative case study, nine participants were interviewed. An important component of qualitative analysis and interview data collection is reaching the point of saturation. This is expressed in the methodology of this study as "no new information or insights are being generated" (Hay, 2016, p. 454). With a small sample size of nine participants, reaching this goal can be seen as problematic. However, well-rounded interview questions were prepared, and rigorous coding and analysis were preformed on the interview data, to reach saturation. Although the findings produced a saturated level of data, more cases within a comparative case study are optimal, as this would include greater geographic differences, unique experiences, and result in different adoptions of the technology.

This study limited scanning of case studies to North America. In respect to research and existing case studies on participatory AR/VR, the geographic area of North America is stagnant compared to Europe. This resulted in a small sample size of cases, many of which are similar in nature. Since scanning was limited to North America, only thirteen cases were found. If scanning included Europe, the potential cases would have expanded from the small pool, and produced more unique adoptive scenarios of the technology.

The scope of this research is meant to overlap AR and VR technology as participatory techniques. Only one case (*Seattle HoloLens*) included in this comparative case study used AR technology. Therefore, the results from this study will not encompass all formats of AR, rather, only the HoloLens technology. Further, HoloLens has similarities to VR technology and is comparatively different than other formats of AR. Meaning, the format of AR discussed in this study is closer to VR than its respective technology. The limitation of this research is the generalisation towards AR, since only one case was discussed. If the scope of this research was expanded, an equal number of cases using AR and VR would be included, producing findings representative of AR and VR equally. Compared to the current representation of this study, it leans towards VR.

Any technology being adopted into citizen participation is being used by citizens. A limitation to this study is not understanding the perspective of the end-users of participatory AR/VR. Sangiambut and Sieber (2016) expressed a similar limitation to their research. Since they were studying the implementation of applications and interviewed those involved in its creation, their results do not capture "the perspective of contributors" (p.152). Citizens could provide insightful perception of the technology, differing from participants in this study. It is necessary for future research to recognise citizen perspectives on the viability of participatory AR/VR.

Chapter 6
Conclusion

As technologies begin to impact citizens in participation processes, it is necessary to further analyse their depth of effectiveness. Governments are leveraging technology for decision-making, yet some forms of technology have not been fully dissected to understand how it might constrain or enable citizen participation. Considering the questions posed in Johnson et al. (2019), (Berger et al., 2016; Janssen & Zuiderwijk, 2014), technologies require deep analysis of their characteristics and implementation to fully understand their affects on citizen participation, and citizen-government interactions. Thus, this research presents AR/VR as a new technology which requires further assessment. In doing so, this study fills a gap in research, and can be used as a mechanism for further studies. It arranges participatory AR/VR by benefits and challenges discovered from adopting the technology in a participation process. These results address characteristics that enable and constrain the technology, by separating findings into themes based on citizens, governments, technological, and participatory.

AR/VR technologies provide a unique approach to engaging citizens in public decision-making. It has the capability in educating citizens on urban planning complexities, by providing contextual information on a project. It has promising characteristics of a participation technique, such as its realistic depiction of project proposals and functioning in co-produced model of participation, however, if applied improperly, it adversely affects participation. There are finite ways of implementing this technology, thus determining AR/VR's benefits and challenges, as per outlined in the research question, allowed this study to propose a framework which suits its capabilities. In the technology's current state and based on its implementation in the case studies, AR/VR is determined as a well-suited visual tool for citizens to identify, discover, and become educated on a project. This finding is based upon the nature of the technology in disseminating complex contextual information through an immersive, realistic, and easy-to-understand visualisation. As a result, the technology is labelled as a beneficial urban planning tool governments can consider implementing. To answer this study's research question, AR/VR requires a strict framework to be considered a beneficial participatory tool. The technology does not appropriately facilitate contributions or participation to the level of comparable techniques. This establishes participatory AR/VR as unviable, and is heavily dependent on the method of implementation.

6.1 Examining the Case Study

Results shed light on the current state of participatory AR/VR. Using a comparative methodology indicated AR/VR has similar tendencies across geographic boundaries in its implementation. The uncovering of themes from the analysis of interview data proves this to be correct. Each case had no prior discussion with the others from this study, however, produced similar responses to the interview questions. The interviews generated beneficial characteristics, such as the educative qualities of AR/VR, realism and immersion through an interactive and novel technology, online and at-home participation, and compatibility with existing GIS and 3D data. Challenges were expressed in similar themes. Constraints of cost, time, and planning were apparent across each case, the private sector of participatory AR/VR impacted the cost and quality of the visualisation, virtual environments lead to false truths and an over exaggeration of the project details, and AR/VR isolates citizens from face-to-face interactions.

Subsequently, the results were discussed in relation to existing research. Findings pertaining to the ability of AR/VR as an urban planning tool reaffirms research stating that the technology has an innate ability in providing contextual information to citizens in an understandable format (Al-Kodmany, 1999, 2001b; Drettakis et al., 2021; Heldal, 2007; Herbert & Chen, 2015; van Leeuwen et al., 2018). The extensive literature review by Stahre Wästberg et al. (2013) provided a discussion on the importance of realism in 3D AR/VR visualisations. This study validates realism as integral for citizens comprehension of city plans, projects, and proposals, as well as understanding complex urban planning terminology and phenomena. Thus, countering research which argues against the importance of realism (Herbert & Chen, 2015) or that realism is entirely dependent on the situation (Billger et al., 2016; Lange, 2005). Realism made it possible for citizens to grasp their spatial surroundings in an AR/VR experience. If realism was missing, it became apparent citizens had trouble connecting the visualisation to their neighbourhood, hence, affecting their ability to provide feedback.

This study relates to existing research on the truth behind a virtual visualisation. Obermeyer (1998) described certain visualisations can lead to false conclusions. The realistic nature of 3D visualisations causes the AR/VR experience to feel real. Over exaggerating or showing an untruthful visualisation is a danger of participatory AR/VR, as mentioned by Al-Kodmany (2002). Costs were constraining to the adoption of participatory AR/VR. Governments want to reduce risks by minimising budgets causing them to overlook AR/VR, and citizens who are unable to afford the technological requirements to use them at-home or online are marginalised. However, at-home and online participation was found to be beneficial since citizens who were shy or unsure of participating in-person, could do so in the comfort of their home. Adopting a co-produced method of citizen participation is possible when using participatory AR/VR, which reaffirms the process outlined by van Leeuwen et al. (2018). Due to the gap in research, other results from this study were unable to be associated with existing cases and research. These findings include the benefit of compatibility in reusing existing 3D models in a virtual environment, mobile units being place on-site of the project, and the technological attraction which brings younger generations into civic processes. Similarly, some challenges were unable to be connected to existing literature. These include a learning curve in understanding how to use the technology, older generations being dismissive, niche and novelty affecting interactivity with the content of the visualisation, disorienting and dizziness when wearing the devices, and an inability of being a standalone participation technique.

6.2 Proposed Framework

As Al-Kodmany (2001b) expressed, participatory AR/VR must follow a structure. This research agrees and designs a thorough framework using AR/VRs capabilities. The technology has transformed since Al-Kodmany's research, where costs have decreased, realism has improved, and smartphones are more powerful than computers in 2001. The basic structure of Al-Kodmany's framework is still in place, however, the growth in technology allows for a more evolved model. It involves having real-time interactions and feedback during the citizen's experience, to obtain the greatest level of feedback, a cheaper and less time-consuming process, and adopting a co-production model of participation where renderings are created through citizen-government partnerships. To reproduce this framework, it requires a platform capable of demonstrating each criterion. Thus, game engines are proposed as the platform of choice for future participatory projects. This decision is based on the capabilities of it in reducing costs and time, but adding interactions and realism, compatibilities with existing work, and a space of co-produced participation. This study elevates Al-Kodmany's framework to a new rung, incorporating the current state AR/VR and findings from this research. This framework represents a response to the potential of AR/VR, by incorporating its capabilities as a participatory tool.

6.3 Recommendations

As new technologies in participation, there must be recommendations put forward to inform governments and urban planners of AR/VR in a participatory setting. There must be an understanding of how, where, and when it should be adopted in citizen participation. What government officials, planners, and my respondents must realise, is that them trying to implement something new to the participatory process, is positive on many fronts. They are showing a willingness in exploring a novel technology to engage their citizens in decision-making. This builds trust in citizen-government relations, and is encouraging for many constituents. However, what governments and planners must understand is that this technology has areas of concern. It has specific purposes of when and where it should be implemented, and is costly and time consuming compared to other tools and methods. To truly move AR/VR forwards, it requires greater accessibility at the private and citizen levels, and a more interactive citizen-first conceptualisation of the technology. Since this technology is niche, levels of accessibility are lower than what it must be to become feasible. Accessibility at the private sector must improve, where governments need to have the option to hire consultants capable of creating renderings for a reasonable price. Further, AR/VR is exclusionary to citizens who can obtain peripherals and have access to the renderings, therefore, if AR/VR is adopted, governments must find ways to incorporate everyone into the process, to not marginalise those who are unable to acquire the means to participate. In terms of interactivity, communication and the model of participation must include the citizen as the focal point of the technology. As a takeaway from this study, there must be an understanding that participatory AR/VR requires a strict framework of adoption, and it must be followed to maintain its potential.

In answering how it should be adopted, governments and planners must follow the proposed framework outlined earlier in this study. In doing so, the framework excels each characteristic of the technology to its fullest potential. The five cases included in this study implemented the technology with similar frameworks, which negated the positive effects of participatory AR/VR. By adopting the proposed best practices, the citizen is central and necessary for the technology to succeed. The difficult question is where and when it should be implemented.

Considering the challenges outlined in this study, AR/VR should not be used for every project, rather, it should be adopted based on certain scenarios. When a project is heavily shifting the look, feel, and characteristics of a space, AR/VR should be implemented so the citizen can see how visceral the changes would be. Many of these aspects relate to connections citizens have with the spaces they live in. When there are plans to affect such spaces, AR/VR can immerse the citizen, making it possible for them to capture the nuances and influences of the proposal. This research is recommending that participatory AR/VR should focus on projects which impact the appearance of a space and require realism in the virtual environment, such as small-scale neighbourhood projects. This would allow citizens to contextualise and understand the full impact of what is being proposed. Further, citizen contributions would have greater quality since they have a connection to the space being changed. Even though governments and urban planners can use AR/VR whenever 3D models are involved, it becomes excessive using it on city-wide projects which focus on a less active role of citizen contributions. AR/VR benefits smaller, intimate, and realistic virtual environments. Truly, when and where participatory AR/VR should be adopted is based on its innate ability to give citizens a realistic and conceptual understanding of how impactful a project can be on a space they have a relationship with.

6.4 Future Research

This study furthers the call for research on technology's influence in participation. The call for research by Johnson et al. (2019) can be used as a stepping stone for future studies, not only with AR/VR, but any technology capable of impacting citizen participation and citizen-government relationships. AR and VR are young participatory techniques. Modifications to the technology and devices will ultimately affect the way they are adopted, perceived, and accepted by citizens and governments. Cheaper devices, hardware, and creation process could alleviate the constraints outlined in this case study. Hence, with future research on participatory AR/VR, researchers must focus on how the technological changes to AR/VR alter its characteristics. This will generate a strong basis that builds upon the findings of this study, and continuously informs citizens and governments of best-case scenarios.

The most important aspect of any participatory technology is citizen interactions. This study limited participants to those who created the visualisation or worked on its implementation. The application of a technology goes two-ways. Future research must assess the perspective of citizens on its use in citizen participation. Citizens could provide countering insight than the findings outlined in this research. It is necessary to compare the government's implementation of AR/VR and how citizen's view its viability as a participatory tool.

AR is not nearly as adopted as its VR counterpart. While this study focused on both technologies, VR was dominant, resulting in a limitation to the results on AR. Future research can focus on why VR is the predominant virtual technology in participatory settings. Since this study had a small sample of AR cases, more research is needed to determine AR's designation in citizen participation.

The literature review discussed the possibility of implementing AR/VR as the technology in a PPGIS framework. The goal of PPGIS is to "incorporate local knowledge, integrate and contextualise complex spatial information, allow participants to dynamically interact with input, analyse alternatives and empower individuals and groups" (Sieber, 2006). Compared to the framework presented in this study, they have similarities. AR/VR is capable of contextualising complex urban information, co-production uses local knowledge, and scenes in a virtual environment is an example of analysing alternatives. What is missing is conceptualising empowerment at the hands of AR/VR. Do costs and time restrictions constrain citizen's access to the technology? Does AR/VR have the capability of empowering citizens? Are AR/VR's qualities viable as a spatial technology in PPGIS? Identifying these questions makes it possible to understand its place in PPGIS.

Not many studies have examined AR/VR as a participation technique. The findings of this thesis address current adopted scenarios of the technology, and highlights key benefits and challenges. It proposes a framework for future projects, as described by the requirements for success. Hence, there is more research required on the adoptability of the outlined framework. This framework must be implemented into a case study, to understand its strengths, weaknesses, and feasibility. Ultimately, the future of participatory AR/VR is dependent on a framework which suits its characteristics. This research laid the groundwork for projects to adopt, but this foundation must be further examined to determine its effectiveness.

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Appendix I – List of Participants

	Case	City	Work Title
Respondent A	Boise 11th Street	Boise, Idaho	Visual communication specialist
Respondent B	Boise 11th Street	Boise, Idaho	Project manager
Respondent C	NRVR	New Rochelle, New York	Project manager
Respondent D	Lethbridge ELUS and SASP	Lethbridge, Alberta	Senior community planner
Respondent E	Lethbridge ELUS and SASP	Lethbridge, Alberta	Community planner
Respondent F	Seattle HoloLens	Seattle, Washington	Strategic initiatives
Respondent G	Seattle HoloLens	Seattle, Washington	Senior urban planner
Respondent H	Seattle HoloLens	Seattle, Washington	Senior public relations
Respondent I	Reimagine Robinson Street	Orlando, Florida	Urban planner/designer

Appendix II – Interview Script

Research Question: What are the benefits and challenges of augmented/virtual reality being used as a participatory tool?

Faculty Supervisor: Dr. Peter Johnson, Department of Geography and Environmental Management, University of Waterloo, Canada. Phone: 1-519-888-4567 ext. 33078, email: peter.johnson@uwaterloo.ca

Student Investigator: Logan Duff-Meadwell, Department of Geography and Environmental Management, University of Waterloo, Canada. Email: lduffmeadwell@uwaterloo.ca

Theme 1: Introduction/the project

1. Can you describe the project you worked on that used AR/VR?
2. How did you use AR/VR?
3. Why did you decide to use AR/VR?

Theme 2: Benefits

1. What are the benefits you have seen from using AR/VR?
    a. Were there benefits you were expecting but did not witness?
2. Are there strengths for its use in decision-making and government processes?
3. Do you think the benefits impact the process in which it was used (open house, focus group, information kiosk)?

Theme 3: Challenges

1. What are the challenges you have seen from using AR/VR?
    a. Were there challenges you were expecting but did not witness?
2. Are there weaknesses for its use in decision-making and government processes?
3. Do you think the challenges impact the process in which it was used (open house, focus group, information kiosk)?

Theme 4: Citizen participation

1. How was citizen participation built into the project?
2. In comparison to non-AR/VR projects, how does the feedback compare?
    a. Would you say this technology influences a change in participation?
3. Compared to workshops, focus groups, consultation process, etc., are there participation aspects that AR/VR has that these other methods lack?
    a. Are there aspects these methods have that AR/VR lacks?
4. Overall, based on your use of AR/VR, does it facilitate participation?

Theme 5: The role of this technology

1. Do you see AR/VR as a viable technology?
    a. Does it have the capability of being a participatory technology?
2. Would you recommend this technology to others who are thinking of using it?
    a. Are there any lessons learned from your experience?
3. Finally, what do you think the future of this technology is?

Appendix III – Interview Recruitment Materials

Recruitment Letter

"Hello,

My name is Logan Duff-Meadwell and I am a Master student working under the supervision of Dr. Peter Johnson from the Department of Geography and Environmental Management at the University of Waterloo, Canada. The reason I am contacting you is that I am conducting a study on the use of augmented reality (AR) and virtual reality (VR) being used for citizen participation. This study will serve as my Master's thesis. The aim of my research is to compare this technology to other participation methods, to see how participation is realised, changed, enhanced or if it remains the same. The objectives of this project are to understand motivations and opinions in adopting or working with AR/VR, so that the benefits and challenges in adopting AR/VR can be determined. The results will assess the role AR/VR fills within government decision-making, and as a technology that may or may not promote citizen participation.

Participation in this study involves a 45 minute to 1-hour video interview. The interview will occur over the Teams video-conferencing platform. The questions you will be asked focus on your work with VR/AR, centering on the benefits and challenges of this technology that you have observed, the way citizens participated (how you received feedback), and your assessment on the role this technology has within decision-making and government activities. Participation in this study is voluntary. You may decline to answer any questions that you do not wish to answer, and you can withdraw your participation at any time. There are no known or anticipated risks from participating in this study. If you worked alongside other government officials for the project in question, you may forward this email to them as part of a snowball sampling method.

It is important to know that your identity will be confidential. For confidential purposes, the video interviews will not be recorded, but the audio will be. All of the data will be summarised and no individual could be identified from these summarised results. The data, with no personal identifiers, collected will be maintained on a password-protected and encrypted hard-drive in a restricted access area of the university.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE #42343).

Should you have any questions about the study, please contact either Logan Duff-Meadwell or Dr. Peter Johnson (peter.johnson@uwaterloo.ca). If you are interested in participating, please respond to this email or contact me at lduffmeadwell@uwaterloo.ca.

Sincerely,

Logan Duff-Meadwell"

Information Letter

Title of the Study: Participatory Augmented and Virtual Reality: A comparative case study recognising its viability in citizen participation

Faculty Supervisor: Dr. Peter Johnson, Department of Geography and Environmental Management, University of Waterloo, Canada. Phone: 1-519-888-4567 ext. 33078, email: peter.johnson@uwaterloo.ca

Student Investigator: Logan Duff-Meadwell, Department of Geography and Environmental Management, University of Waterloo, Canada. Email: lduffmeadwell@uwaterloo.ca

To help you make an informed decision regarding your participation, this letter will explain what the study is about, the possible risks and benefits, and your rights as a research participant. If you do not understand something in the letter, please ask one of the investigators prior to consenting to the study.

What is the study about?

You are invited to participate in a research study about augmented reality and virtual reality as technologies used to engage citizens in the government decision-making process. Trying to implement proper methods of participation has been a problem for decades and with the increased use of technology in government activities, augmented reality and virtual reality fit with this narrative. The objectives of this study are to understand the motivations and opinions in working with AR/VR and to determine the benefits and challenges in adopting this technology. The intention is to address the role AR/VR fills within government participatory processes.

This study is being undertaken as part of my (Logan Duff-Meadwell) Masters thesis.

I. Your responsibilities as a participant

What does participation involve?

Participation in this study will consist of attending one interview. The session is expected to last 45-60 minutes. Interviews will be held over the video-conferencing software Teams at a time and date convenient to you. You will be asked questions based on the AR/VR project they worked on. Questions range from your work related to the project, the benefits and challenges faced in using AR/VR, how citizen participation is built into the project, and the role AR/VR has in government processes.

The session will be audio recorded to ensure an accurate transcript of the interview. With your permission, anonymous quotations may be used in publications and/or presentations.

Who may participate in the study?

In order to participate, you must be older than 18 years of age and have worked on, closely or planning on using AR and/or VR as a civic participatory technology.

II. Your rights as a participant

Is participation in the study voluntary?

Your participation in this study is voluntary. You may decide to leave the study at any time by communication this to the researcher. Any information provided up to that point will not be use. You may decline to answer any question(s) you prefer not to answer. You can request your data be removed from the study up until August 1st 2021 as it is not possible to withdraw your data once the results have been submitted for publication.

Will I receive anything for participating in this study?

You will not receive payment for your participation in the study.

What are the possible benefits of the study?

Participation in this study may not provide any personal benefit to you. I hope the data from the interviews will benefit society in determining AR/VR as a new and different technology governments can use to engage citizens in the decision-making process. The study will also benefit the academic community by addressing the technology's participatory nature.

What are the risks associated with the study?

The interview will be conducted over Teams. When information is transmitted over the internet, privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party (e.g., government agencies, hackers). University of Waterloo researchers will not collect or use internet protocol (IP) addresses or other information which could link you participation to your computer or electronic device without first informing you.

Will my identity be known?

The research team will know which data is from your participation.

Will my information be kept confidential?

Your identity will be confidential. Identifying information will be removed from the transcripts. Audio recordings, transcripts and other electronic data will be retained for a minimum of 7 years. Any paper files will be retained for a minimum of 1 year. All electronic files will be encrypted and stored on a password protected hard-drive in a secure location at a personal computer which is only accessible by the researcher. No identifying information will be used in my thesis or any presentations or publications based on this research.

III. Questions, comments, or concerns

Has the study received ethics clearance?

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE #42343). If you have any questions for the Committee contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca

Who should I contact if I have questions regarding my participation in the study?

If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact Logan Duff-Meadwell at lduffmeadwell@uwaterloo.ca

Logan Duff-Meadwell, MA

Department of Geography and Environmental Management

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Verbal Consent Script

Title of Study: Participatory Augmented and Virtual Reality: A comparative case study recognising its viability in citizen participation

"Hello. As presented in the information letter, I am researching augmented/virtual reality use across North America as technologies used to engage citizens in decision-making processes. I also want to understand the technology's benefits, challenges, and role it has within government activities.

This interview will range between 45 and 60 minutes. Questions asked will be from the AR/VR project you worked on. Some examples of questions are the benefits and challenges of the project, how citizens participated and the type of feedback you received. With your consent, the interview will be audio recorded to ensure accurate transcription and analysis. Your identity will be confidential.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE #42343).

I want to remind you that your participation in this study is voluntary and you can withdraw your consent at any time. Your answering of consent will be documented on paper.

- Do you give consent to be interviewed for this study?
- Do you give consent for the use of audio recording to ensure accurate transcription and analysis?
- Do you give consent for the use of anonymous quotations in any thesis or publication that comes from this research?

Thank you."