Introducing the Smart City to Children

Clarinval, Antoine; Simonofski, Anthony; Henry, Julie; Vanderose, Benoit; Dumas, Bruno

Published in:
Sustainability

DOI:
10.3390/su15031774

Publication date:
2023

Document Version
Publisher's PDF, also known as Version of record

sustainability

Article

Introducing the Smart City to Children: Lessons Learned from Hands-On Workshops in Classes

Antoine Clarinval *, Anthony Simonofski, Julie Henry, Benoît Vanderose and Bruno Dumas

Namur Digital Institute, University of Namur, 5000 Namur, Belgium
* Correspondence: antoine.clarinval@unamur.be

Abstract: Smart cities are receiving a lot of attention from researchers and practitioners as they are considered potential solutions to challenges (e.g., traffic congestion and waste management) faced by cities. As a result, the term "smart city" is recurring in political discourses and the news. Moreover, smart cities are transitioning from strong and technological orientations toward inclusive and participative orientations, and citizens are expected to take an active part in their design. However, the smart city concept remains obscure to the majority of the public; although many participation methods exist for adults, few have been implemented for children, who remain on the sidelines. Our objective is to address the lack of research on innovative initiatives to (1) educate children on the smart city concept and (2) include them in citizen participation dynamics. To achieve this, we propose a novel hands-on workshop where children learn about the smart city concept, are challenged with a collective urban planning exercise and develop a digital citizen participation method. This paper describes the workshop conducted and reports on lessons learned from its evaluation; the workshop involved 299 children from the ages of 12 to 14. It showed success in improving the children's understanding of the smart city concept. We then propose future inclusive smart city research directions grounded in the evaluation results and the feedback received from multiple practitioners.

Keywords: smart city; inclusive citizen participation; urban planning; children; in-class workshop; educational activity

check for updates

Citation: Clarinval, A.; Simonofski, A.; Henry, J.; Vanderose, B.; Dumas, B. Introducing the Smart City to Children: Lessons Learned from Hands-On Workshops in Classes. *Sustainability* **2023**, *15*, 1774. https://doi.org/10.3390/su15031774

Academic Editors: Aggelos Tsakanikas and Panagiotis Panagiotopoulos

Received: 2 December 2022
Revised: 7 January 2023
Accepted: 11 January 2023
Published: 17 January 2023

1. Introduction

In the twenty-first century, the population is expected to concentrate more on cities. This urbanization raises complex challenges, such as mobility issues, waste management, security, climate change, and access to resources [1]. In this context, smart cities have emerged as a potential solution to tackle these urban issues [2] using the full range of emerging technologies [3]. At first, this concept focused on technology with complex information systems and the Internet of Things facilitating the working of urban infrastructures [4,5]. However, too often, smart cities did not reach their objectives because they assumed citizens' needs and pushed technological solutions without taking into account the specificities of their territories and inhabitants [6]. Thus, many research studies have criticized the focus on technology, arguing that citizens should be involved early in the design of smart cities [7,8] and that smart city policies should be formulated according to specific socioeconomic situations and population needs [9]. In this context, technology is a necessary (but not sufficient) condition for a smart city [10,11] and it should be considered as a means to empower citizens [12,13]. In this line of thought and based on the definitions of [14,15], we define a smart city as a city that provides innovative solutions, in collaboration with its citizens and with the support of technology, to solve the specific challenges of its territory in the domains of mobility, economy, governance, environment, living, and people. This definition shows how critical the participation of citizens is for a smart city to succeed.

In this paper, we focus on a sub-group of the citizenry, namely children. Previous studies have shown that the participation of children is important for the democratic vitality of a city [16–18], beneficial to their skill development [19], and prepares them for adult participation [20,21]. UNICEF, through the child-friendly city concept [22,23], also calls for the participation of children in public issues as it is part of their rights. On the contrary, according to [24], excluding children from participation can have problematic consequences, such as increased inequalities, loss of confidence in democratic processes, infrastructure being inadequate for children, and a reduction in place attachments.

Several smart city initiatives for children have been published, with objectives such as well-being improvement [25] and the creation of learning experiences [26]. However, these initiatives focus on how smart cities can provide services to children but not how children can be active actors directly affecting the decisions. A few solutions allowing the involvement of younger audiences have been published [27,28]; participation from children in urban planning is advocated as long as it is organized in a way that is adapted to their capacities [29], for example involving games [30]. However, such efforts remain scarce, and children are, in practice, left behind in smart city participation initiatives [23,31], whereas a wide range of methods has been proposed for adult participation [10,32–35]. For example, children's needs in urban planning are mainly taken into account via adult representatives in Norway, while the country is one of the most advanced regarding children's rights in this matter [36]. Still, studies show that most children are willing to have opportunities to be involved in decisions [37,38]. Therefore, we formulated Research Gap 1: "**Lack of innovative participation opportunities for children in the smart city**".

In addition to the lack of participation initiatives destined for children, another important aspect involves preparing them to actually participate. Indeed, the early preparation of children (regarding participation) is key for their involvement in decision-making [22,23] and future participation as adults in smart cities [39]. The lack of preparation for participation, especially when performed online, can lead to a participation divide between sub-groups of the citizenry [40]. An essential part of this preparation is to introduce fundamental concepts, e.g., smart cities and citizen participation, to children. A similar idea is also advocated in the spatial citizenship literature studies, which emphasize that spatial skills are essential prerequisites for participation activities, as in many cases they involve working with geographical representations [41]. Several works have focused on integrating these skills into secondary education to allow children to participate in these activities [42,43]. Regarding smart cities, despite education being considered a key component [44–46], efforts in the education of children have either focused on increasing the digital literacy of citizens [47,48] or on using new technologies to support in-class teaching activities [46,49], which contribute to improving the digital literacy skills of students. One perspective on education that is rarely explored in the literature involves education and the concept of smart cities (including its ins and outs for citizens). This is needed, as the smart city concept remains difficult to grasp for the larger public, including children, due to the multiplicity of definitions and terms to qualify it [50], the absence of a general consensus [10], and the fuzzy political discourse [51]. Yet, it is important for citizens to be aware of the smart city (and of their role within it) to become engaged in this paradigm [52,53]. A recent literature review highlighted a few studies and focused on introducing the smart city concept to children [54]. However, they only addressed the technical aspects of smart cities and focused on introducing children to new technologies, programming, or designing smart things (e.g., the SNaP workshop [55]). To the best of our knowledge, no activity introduces the smart city concept to children while covering aspects related to citizen participation. Therefore, we formulated Research Gap 2: "**Lack of initiatives to educate children to the concept of smart city and its participatory aspect**".

We tackle these two gaps by proposing a workshop destined for children. Research Gap 1 offers an opportunity for children to participate in the context of a smart city. Therefore, we formulated our first research question: "What elements do children consider as important in a workshop to participate in the smart city"? Research Gap 2 represents an introduction to this fuzzy concept. Thus, we formulated our second research question: "To what extent can the proposed workshop impact children's understanding of the smart city concept"? To provide insight into these research questions, we conducted a thorough assessment of our workshop with 299 participating children from the ages of 12 to 14.

The remainder of the paper is structured as follows. Section 2 details the methodology for the workshop development as well as how we collected and analyzed the data from the workshop evaluation. In Section 3, we describe the content of the workshop and the findings from its evaluation. In Section 4, we discuss leads for workshop improvements, the limitations of our study, and future work directions. Closing comments are provided in Section 5.

2. Materials and Methods

2.1. Workshop Development

To develop the workshop, we worked through several cycles following the best practices of design science [56] as shown in Figure 1. Design science is an iterative research methodology that consists of creating an output linked with technology to serve a human purpose. This output is, in our case, a workshop. First, we performed an initial literature review to discover ideas about the structure of the workshop. Following this review, we relied on participatory design principles as this method is helpful for including children in planning processes [57,58]. Moreover, we relied on future workshop techniques as they enable non-experts to imagine innovative solutions to solve issues in urban planning [59]. This initial literature review also constituted the rigor cycle as we identified research gaps in the knowledge base to be answered by this workshop. Second, with an initial version of the workshop based on these sources and knowledge from the smart city literature, we improved it in close collaboration with two research experts in digital education. One has experience with training teachers on how to introduce programming to children, and both have experience with teaching programming to children. Third, we tested the workshop through an in-school session that enabled us to improve it based on the class experience and the feedback from children and teachers. Finally, we received early feedback on the workshop content and the results of this session from local conferences and expositions on digital education (Educode (https://www.digitalwallonia.be/fr/cartographie/educode/, accessed on 1 December 2022), Ludovia (https://ludovia.be/, accessed on 1 December 2022), EIAH (https://eiah2019.sciencesconf.org/, accessed on 1 December 2022), and SETT (https://www.sett-namur.be/, accessed on 1 December 2022)). The feedback was from teachers (mostly from secondary schools) and researchers in digital education who worked in Belgium, France, and Switzerland, as well as from public servants. These presentations and the testing of the workshop documented in this paper contributed to the relevance cycle. Indeed, we ensured that the workshop contributed to its environment and answered the educational needs of children as well as the objectives of teachers.

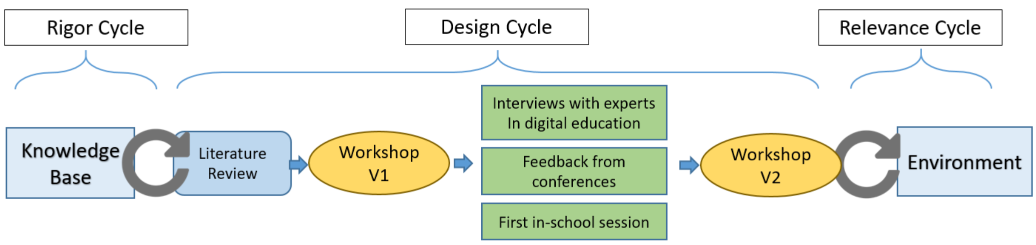

Figure 1. Methodology followed for the development of the workshop, following design science research principles.

2.2. Data Collection

To test the workshop in real-life conditions, we performed field experiments in classrooms following the best practices of educational research [60–62]. The school setting is well-suited for citizen participation as it mitigates unequal power relationships [38], and citizen participation implemented through schools is taken more seriously by parents [63]. Following the children and youth categories presented in [64], we set our target group to teenagers (i.e., 13–18 years old), as they are a high priority in social involvement. Participating schools were recruited on voluntary bases based on the network of schools present in the School-IT project (https://school-it.info.unamur.be/, accessed on 1 December 2022). Our call for participation received interest mainly from teachers teaching in first, second, and third secondaries; that is, children between the ages of 12 and 14. In response to these participation requests, we adapted our target group accordingly and included 12-year-old children. All of the workshops were led by two researchers in the presence of the class teacher. Four workshops were given to classes that visited the campus in the context of an event hosted by the researchers' universities. For the other workshops, the researchers went to the children's schools and the sessions were given in their classrooms. Regarding education type, most of the children were enrolled in general education but the workshop was given to children in specialized and differentiated education as well. *General education* refers to the conventional education path that prepares pupils for graduate studies. *Specialized education* allows a pupil to evolve at his or her own pace, thanks to the pedagogical guidance that allows for educational individualization. This type of education includes pupils with mental retardation and behavioral problems. *Differentiated education* is a type of secondary education used to manage and reduce disparities among pupils, manage class heterogeneity, and reduce grade repetition. It is intended for pupils who have not graduated from primary school. Table 1 provides detailed information for each session.

Table 1. In-school sessions of the workshops that were organized. The location, the workshop format, the school year, the education types that participating children were enrolled in, the number of participants, and the number of questionnaire pairs collected are indicated for each session.

Location	Format	School Year	Education Type	Number of Participants (Females)	Number of Questionnaire Pairs Collected (Females)
Namur	2 × 100 min	2nd secondary	General	25 (11)	21 (9)
Namur	2 × 100 min	3rd secondary	General	16 (6)	15 (5)
Campus	1 × 90 min	3rd secondary	General	14 (7)	0 (0)
Campus	1 × 90 min	5th secondary	General	15 (11)	0 (0)
Campus	1 × 90 min	5th primary	Specialized	16 (7)	0 (0)
Campus	1 × 90 min	5th primary	Specialized	10 (4)	0 (0)
Namur	2 × 100 min	2nd secondary	Differentiated	16 (0)	10 (0)
Namur	2 × 100 min	2nd secondary	Differentiated	7 (0)	5 (0)
Ottignies	2 × 50 min	1st secondary	General	22 (9)	14 (1)
Ottignies	2 × 50 min	2nd secondary	General	25 (12)	19 (9)
Ottignies	2 × 50 min	2nd secondary	General	21 (6)	0 (0)
Ottignies	2 × 50 min	2nd secondary	General	23 (14)	19 (12)
Ottignies	2 × 50 min	1st secondary	General	21 (2)	0 (0)
Ottignies	2 × 50 min	2nd secondary	General	20 (10)	0 (0)
Ottignies	2 × 50 min	2nd secondary	General	24 (12)	7 (3)
Namur	1 × 150 min	2nd secondary	General	24 (13)	20 (11)
				299 (124)	**130 (50)**

However, the teaching hours available for the workshop did not always match the conduct as initially devised. This resulted in four different formats being designed. Some involved giving the workshop in two parts separated by one to two weeks. The formats are detailed in Table 2.

Table 2. Conduct descriptions of the four existing formats of the workshop.

Teaching Hours	Conduct
Two sessions of 100 min	The first 100-min session was dedicated to the first two steps of the workshop. The second session was dedicated to the third step. The steps were conducted as described in Section 3.1.
Two sessions of 50 min	The first 50-min session was dedicated to the first two steps of the workshop. However, the animators presented one example per dimension in the first step. In the realization of the model, the model modification round was skipped. The second session was dedicated to the third step. Less time was given to the children to complete the exercise and less time was dedicated to the discussion after the presentation of the solution.
One session of 150 min	The city model was built beforehand by the children in the context of another class activity. Thus, the realization of the model step was skipped and the identification of issues could start right after the theoretical introduction. This allowed conducting the first and third steps as described in Section 3.1.
One session of 90 min	Due to timing constraints, the theoretical introduction was accelerated by discussing fewer examples with the children. The discussions on participation methods were also skipped to have enough time to build the city model. Rather than a hands-on exercise, the third step was replaced by a brief introduction to the micro:bit programming interface and a demo on how to build a voting system with it.

When feasible, we collected data through two paper-based questionnaires following pre-test-post-test designs [65,66]. The use of paper questionnaires allowed us to provide additional information if one child could not understand some questions. Pre-test and post-test questionnaires allowed for measuring the impacts of an activity on a group of individuals. This matches perfectly with our two research goals.

We asked the children to complete the pre-test questionnaire before the workshop and the post-test questionnaire after the workshop. Due to practical constraints, only ten to fifteen minutes could be allocated for each, which limited the number of questions that we were able to include. All questions were open-ended to allow richer answers from children. The questions in the pre-test were the following:

- For you, a city is: …
- For you, a smart city is: …
- Mention the positive and negative points of a group discussion: …

Group discussions were central to the conduct of the workshop due to the focus on citizen participation. Hence, the goal of the third question is to understand which elements were important for children in a group discussion. In the post-test questionnaire, the third question was related to the workshop specifically instead of group discussions to assess the workshop against the elements identified in the pre-test for future improvements. In addition to the three questions, we asked two additional questions in the post-test:

- What is the "smart city" project you would like to see in your city?
- How would you ask the public's opinion on a "smart city" project?

Although 299 children participated in the workshop sessions, the data collected through the questionnaires related to a smaller sample. This was caused by several issues that occurred during the data collection. First, due to time constraints, the questionnaire could not be completed by the children participating under the 1×90 min format, as requiring them to do so would not have left enough time to complete the workshop. Nonetheless, valuable observations and feedback from the teachers could be collected. Second, the workshops under the 2×50 min format were hosted by a substitute teacher who was in charge of the classes only during the workshop times. This caused confusion, which prevented data collection regarding important parts of the children. Third, children who did not attend a class led to them only taking the pre-test or the post-test. Overall, 52 (resp. 59) children only completed the pre-test (resp. post-test), and 130 complete questionnaire pairs were collected. For 16 of these 130 children, however, the questions specific to the post-test were not answered (there was confusion in the paper questionnaires and those children completed the pre-test before and after the workshop). Therefore, the findings presented in Section 3 relate to 130 children for the smart city definition and 114 children for the other aspects. Overall, data could be collected for the differentiated and general education types, and across the first, second, and third secondaries. However, for the first and third secondaries, data were obtained for only one class.

2.3. Data Analysis

Since all the questions asked in the questionnaire were open-ended, we relied on the manual coding of answers to draw conclusions about the collected data. Two researchers performed the coding independently and compared their respective results. The answers not coded alike by the two researchers were discussed with a third analyst to reach a consensus. Instead of defining a final list of codes beforehand, an exploratory coding methodology was used, where few codes were defined and refined throughout the coding process [67].

The analysis of the responses to the first question was not reported. The goal of the question was not to collect data related to the research objectives but rather to start the questionnaire with a question that each child would have an answer, in order to not 'daunt' answering from the beginning with a more complex question [68]. The responses children gave to the questions were too generic (i.e., they explained that a city is a group of people living together) and, therefore, irrelevant to analyze in the context of this research.

The definition of the smart city given by the respondents was first analyzed with hypothesis coding [69], according to the two smart city orientations commonly found in the literature and practice (*technology* and *participation*). Table 3 summarizes the codes and gives an example (from the collected data) for each. The *intelligent people*, *autonomous*, and *futuristic* codes are referred to as misconceptions, as they correspond to incorrect conceptions of the smart city. The seven codes are not exclusive. For instance, according to the list of codes in Table 3, a definition stating that a smart city uses flying cars to ease citizen travel would fall under the *technology*, *problem-solving*, *citizen problem*, and *futuristic* labels. In addition to the labels, the smart city dimensions mentioned in the definition were also noted. In the aforementioned example, the smart city dimension at hand would be *mobility*.

The question asking children about the smart city project that they would like to see in their city was coded following the smart city dimensions and the codes used to analyze the smart city definition. As a project proposition corresponds to suggesting a solution to a problem, the *problem-solving* code was not used in the analysis of this question.

The question regarding the advantages and disadvantages of group discussions and the workshop was analyzed by extracting all individual elements mentioned and grouping the ones referring to the same idea together into categories following exploratory coding practices. Categories were defined and refined incrementally.

The answers to the question regarding the participation processes children would use when asking for the public's opinion were analyzed by extracting any explicitly mentioned citizen participation process. For each process, three characteristics were noted. The *decision* indicates whether the participation process results in a decision (vote) or merely consists of polling the public (poll). The *digital* character indicates whether the proposed process involves ICT. Lastly, the *method* refers to the concrete means used (e.g., application, website, door-to-door). It may occur that one or several of these three characteristics do not appear explicitly in the proposed process. In these instances, the process was described only with the elements that could be extracted. In cases where a respondent proposed several participation processes, all of them were noted and described separately.

Table 3. Codes assigned to the smart city definitions.

Code	Description and Example
technology	The smart city contains ICT Example: a city where there is a lot of technology
problem-solving	The smart city attempts to solve general problems Example: a city where technology is mainly developed and that finds solutions to problems
citizen problem	The smart city attempts to solve general problems and those problems are faced by citizens Example: a city where leaders are trying to find ideas to make the city greener and more pleasant for citizens
participation	The smart city involves citizens in decision-making Example: it is a city in which everyone has the right to have his/her own opinion and to share it via technology, in particular
intelligent people	The smart city has intelligent inhabitants Example: a city with only intelligent people
autonomous	The smart city is automatized and able to work without citizens Example: a city more focused on technology, a city that manages itself
futuristic	The smart city has science fiction technology (e.g., flying cars, serving robots) Example: an organization of buildings controlled by intelligent and artificial robots
no answer	No definition was provided

3. Results

3.1. Workshop Conduct

The workshop is composed of three main steps that are briefly summarized below. More details on its content can be found in the authors' previous work [39].

First, in the **theoretical introduction to the smart city** step (referred to as Step 1), we present the children with a poster illustrating the six smart city dimensions as conceptualized in [44]. Then, we ask children to assign the right dimension(s) to examples of typical smart city solutions (e.g., CCTV cameras).

Second, in the **collective urban planning** step (referred to as Step 2), we present the children with a city map in the form of a 2D paper plan with an unbuilt map printed on it. The unbuilt map is an abstracted geospatial map of an existing city. The buildings are not shown on the map, which displays only the roads, green areas, and watercourses. Then, we divide the class into four groups of even sizes and provide them with 15 buildings from the participatory role-playing game Democracity (https://www.belvue.be/nl/activities/speeldoos-democracity, accessed on 1 December 2022). Democracity allows players to form political parties, draw up programs, and build a city. Then, we ask the children to debate and work as a local community council to select three buildings to place on the map. After building the first version of the city, we allow each group to suggest one modification to the city model, such as adding a building, moving a building, etc. Figure 2 shows the city model that was built by the children during one of the workshops. The choice of holding a collective urban planning exercise is motivated by the potential of this approach in involving children, as highlighted by the literature presented in Section 1 and by the output of the exercise, allowing for a common discussion workspace needed for the subsequent part of the workshop. We keep the exercise simple (e.g., by not attributing the political party roles from the Democracity game and by starting from an unbuilt city map) to ensure that it is adapted to the capacities of the children and to the timing constraints.

Figure 2. Example of a city model built by children during one of the workshops.

Third, in the **identification and resolution of issues** step (referred to as Step 3), we give children the opportunity to reflect on the potential urban issues that could happen in the current city model. These issues can be represented in the city model directly. After selecting one issue to tackle (i.e., after reaching a consensus through discussion or voting), we ask the children to think about potential solutions to solve this issue. Children can take inspiration from the smart city solution examples of Step 1. The solution chosen by the children is then implemented thanks to programmable devices suitable for novice programmers, such as Makeblock Orion (https://www.makeblock.com/project/makeblock-orion, accessed on 1 December 2022) or micro:bit (https://microbit.org/, accessed on 1 December 2022). The Makeblock Orion is a control board in which various sensors (e.g., temperature, movement) can be plugged in to build a solution, and the micro:bit is a pocket-sized computer equipped with sensors, physical buttons, and a screen with 25 LED lights for display. We relied on such tools because previous works noted that technologies could increase children's interests in areas that are less attractive to them [64]. Since the workshop focuses on citizen participation, children reflect on solutions related to participation methods. In the workshops, they develop decentralized voting systems using technology. The micro:bit is used because of its small size and the buttons it provides (e.g., it resembles a voting box), as well as its ability to communicate with other devices, which allows for easy aggregation of the votes from micro:bit. The children, by groups of two, implement voting boxes that are able to communicate with a vote counter displaying the aggregated results (Figure 3). Figure 4 (left) shows the program written for micro:bit by the children using block programming. The program indicates that if the user presses "A", an "in favor" vote will be sent to the vote counter and a smiley face will appear on the micro:bit screen represented in Figure 4 (right).

Figure 3. Vote counter displaying the aggregated results from the voting boxes developed by the children. The question asks children to express their opinions on the relocation of the mall.

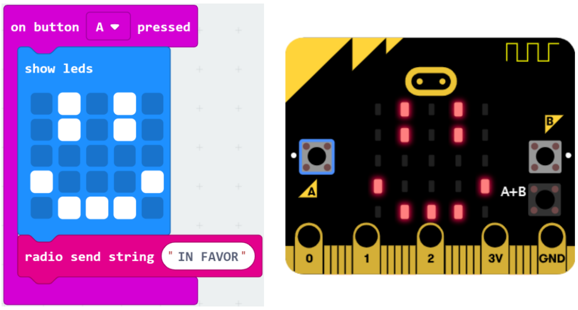

Figure 4. Code (**left**) and execution (**right**) of the voting box developed by the children using the micro:bit.

3.2. The Workshop as an Educational Tool

3.2.1. Smart City Definition

Figure 5 shows the number of definitions that were assigned to the different codes by the children, as well as the number of children who did not provide answers to the questions, either by writing that they did not know (or they did not write anything); 35 of the 130 definitions were answers that did not match any codes. In most cases, they corresponded to children defining a smart city as an environment-friendly city, thus relating to the environmental dimension but no code. The *technology* code was still strongly present after the workshop. However, a substantial increase can be observed for the *problem-solving*, *citizen problem*, and *participation* codes. As for the misconceptions, they decreased overall. The number of children who did not answer the question or whose answers did not match any code decreased by approximately half. No significant difference between males and females was found.

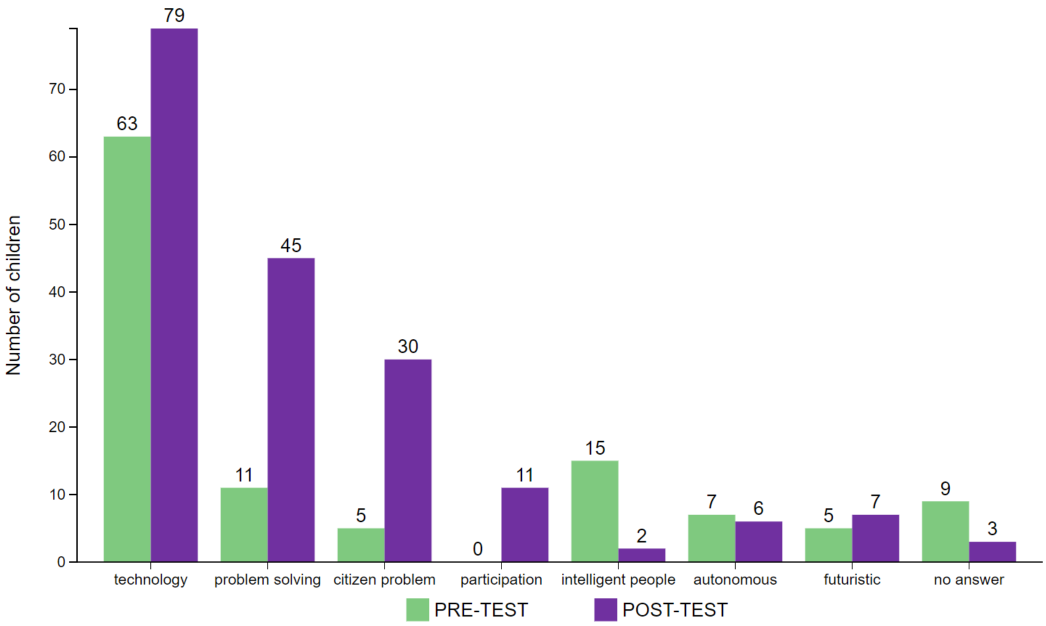

Figure 5. Number of smart city definitions assigned the different codes, for the pre-test and post-test questionnaires (n = 130).

Although comparing the assignation numbers for each code before and after the workshop is insightful, it is essential to analyze the transition between these different visions. To achieve this, a fingerprint was associated with each smart city definition from the tags assigned. In total, five distinct fingerprints were defined from the initial codes (see Table 4).

Table 4. Fingerprints associated with the smart city definitions.

Fingerprint	Description
technology	Only the *technology* code was assigned
good	Either the *problem-solving*, the *citizen problem*, or the *participation* code was assigned, regardless of any other present code
no code	The question was answered, but no code was assigned
misconception	Neither the *problem-solving*, the *citizen problem*, nor the *participation* code was assigned AND either the *intelligent people*, *autonomous*, or *futuristic* code was assigned
no answer	The question was not answered

Figure 6 shows a Sankey diagram representing how children shifted from one fingerprint to another in the smart city definitions that they gave in the pre-test and post-test. The most frequently assigned fingerprint changed from *technology* to *good*. In fact, the frequencies of all fingerprints except for *good* decreased after the post-test, many children have transitioned to this fingerprint.

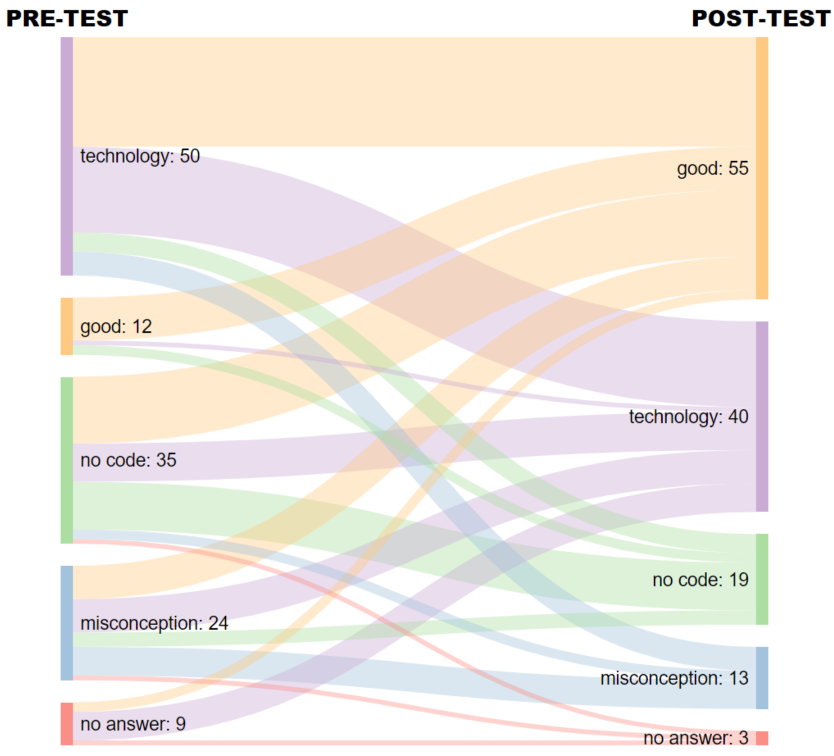

Figure 6. Sankey diagram representing how children shifted from one fingerprint to another in the smart city definition they gave in the pre-test and post-test questionnaire (n = 130).

Figure 7 shows the number of times the smart city dimensions are mentioned in the definitions for the pre-test and the post-test questionnaires. *The environment* is the smart city dimension mentioned the most in the definitions. In many instances, a smart city is defined as a city that respects the environment, an ecological city (e.g., "an ecological city, with less pollution and more greenery"). Another recurring dimension is *mobility*. This dimension often appears in the technology orientation, as children frequently exemplify the use of technology with transportation means. It also appears in the environment dimension. Some children pushed their thinking further when they defined a smart city as environment-friendly by providing concrete solutions (e.g., "a city with fewer cars and more bicycles"). Conversely, the *economy*, *people*, *governance*, and *living* dimensions are mentioned marginally.

They cover aspects of urban life that are of lesser concern to children, such as employment, citizens' level of qualification, and public services. However, due to its larger scope, more occurrences of the living dimension were expected. Instead of mentioning areas such as health and tourism, four of the five definitions from the pre-test (in the living dimension) discussed examples of using technology to improve security (e.g., "a city where there are surveillance cameras"). The majority of the proposed definitions do not explicitly mention any of the six smart city dimensions. For the main part, they correspond to definitions where misconceptions of the smart city appear (e.g., "a city where there are only intelligent people"), where the smart city is solely defined by the presence of technology, or to the absence of answers for the questions.

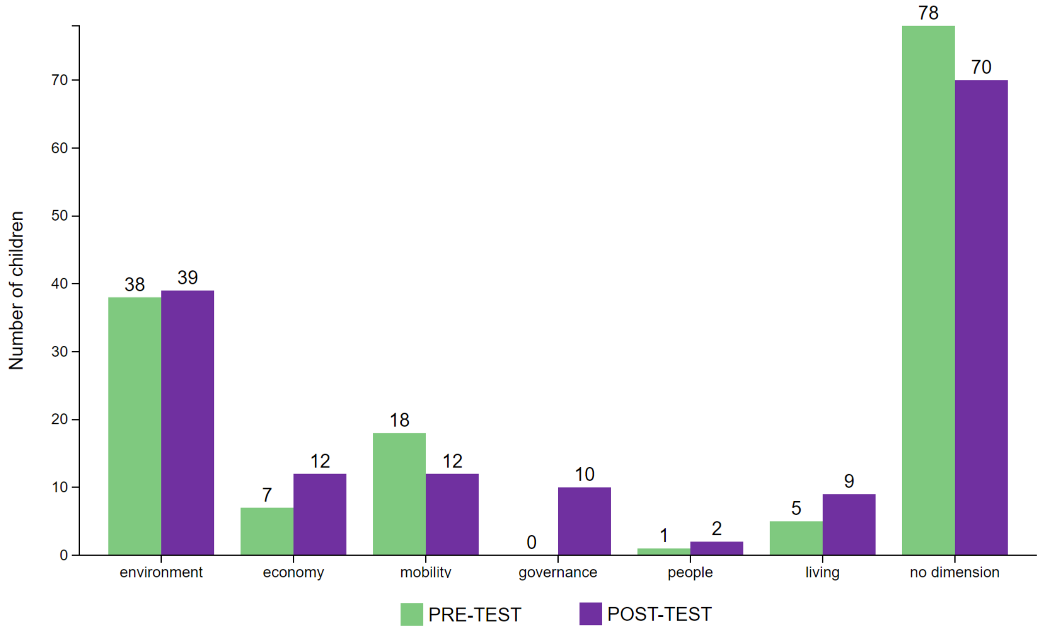

Figure 7. Number of times the smart city dimensions are mentioned in the definitions, for the pre-test and the post-test questionnaires (n = 130).

In the post-test, the economy, living, and governance dimensions have more occurrences and the mobility dimension is less frequent. The increase is especially striking for the governance dimension, which appeared in 10 definitions while being totally absent from the pre-test. Unlike the pre-tests, some children also defined the smart city as a city that works to solve problems, without explicitly mentioning the dimension into which these problems fall (e.g., "a city that innovates and finds solutions to the problems of its citizens").

3.2.2. Smart City Project

Concerning the orientations of the project ideas, half involved *technology* (see Figure 8). The other two presented *participation* and *futuristic* orientations. Moreover, 18 children did not provide any answer to the question or stated that they did not know what smart city projects to propose. One type of response that we discriminated from this involved answers stating that no smart city project was wanted, as the city was already fine as-is. Four children answered the question as such; 39 children proposed a smart city project that did not match any orientation (*no code*). These are, for the most part, projects consisting of more sustainable behaviors, such as garden projects or free public transport.

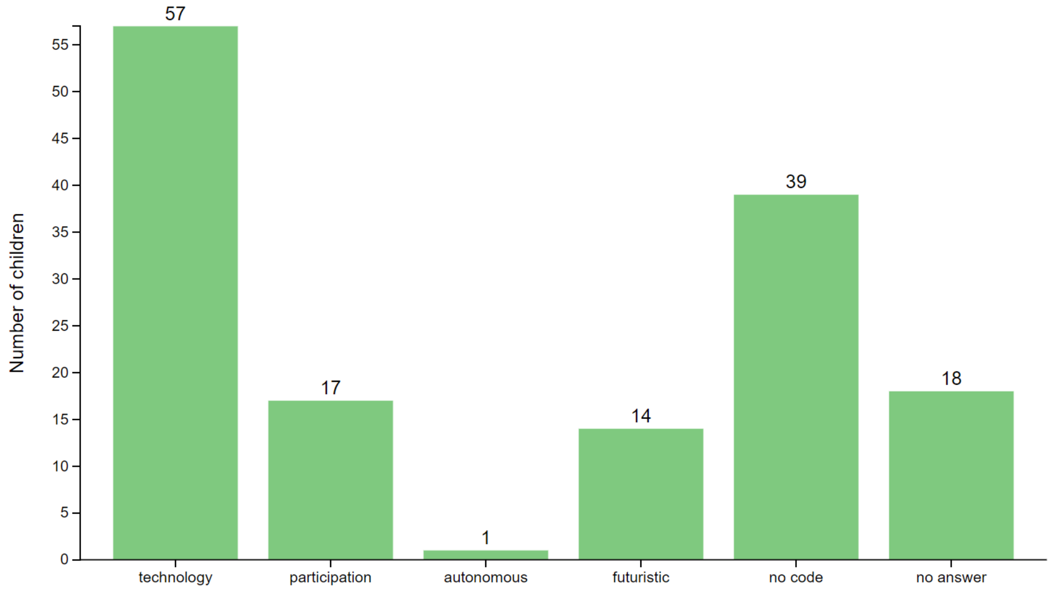

Figure 8. The number of smart city projects assigned the different codes (n = 114).

The smart city dimensions mentioned in the proposed projects were extracted as well. Overall, two dimensions stand out, namely *environment* and *mobility* (see Figure 9). We observed that the environment and mobility appeared together in many project propositions; the most frequent solution suggested tackling environmental issues by promoting public transport and bikes at the expense of cars. As for the *governance*, *living*, *people*, and *economic* dimensions, they appeared less frequently, either by reusing the examples presented during the first step of the workshop (e.g., smart bins and smart lightning) or by proposing voting systems. In some instances, the children's personal contexts made mobility projects emerge, such as adding a specific bus line to better accommodate their own transportation needs. Finally, there were many project propositions in which no dimension was explicitly mentioned. They mainly included the absence of an answer, answers stating that no project was wanted, and projects that solely proposed adding technology to the city (e.g., "more technology in the city").

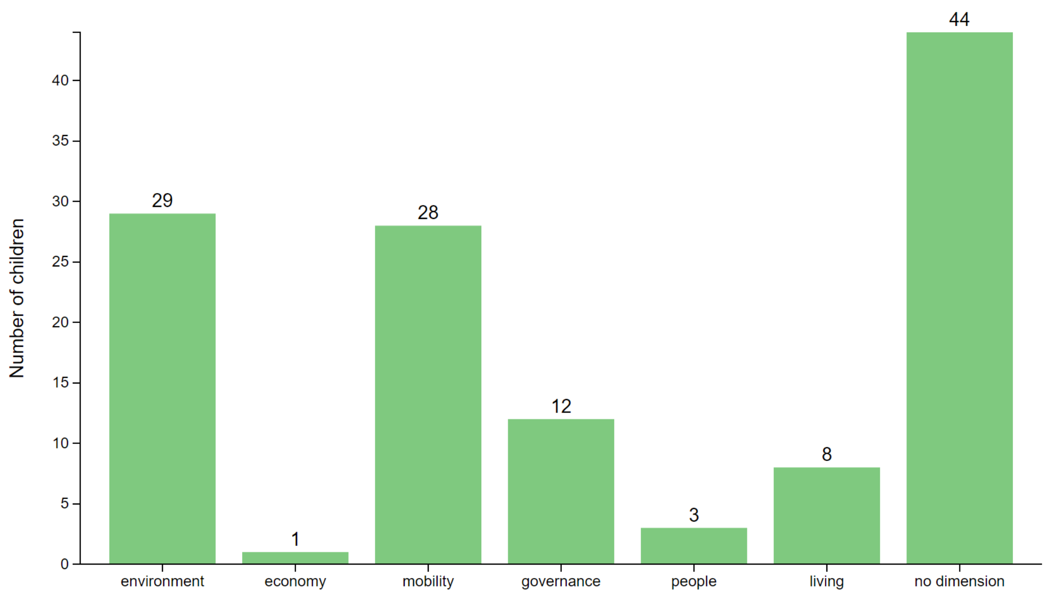

Figure 9. Number of times the smart city dimensions were mentioned in the projects (n = 114).

3.2.3. Participation Methods

A total of 21 children did not propose any participation process, 79 proposed 1 process, 13 children noted 2 processes, and 1 child listed 3. In total, 108 participation processes were described. Figure 10 shows a tree diagram regrouping all of the participation processes proposed by the children. The second, third, and fourth level nodes of the tree are related, respectively, to the *decision*, *digital*, and *method* characteristics. A path in the tree defines a participation process characterized by each node it crosses. The number of times a participation method is proposed is noted between parentheses along each leaf node. The greater order frequencies are noted along the internal nodes of the tree.

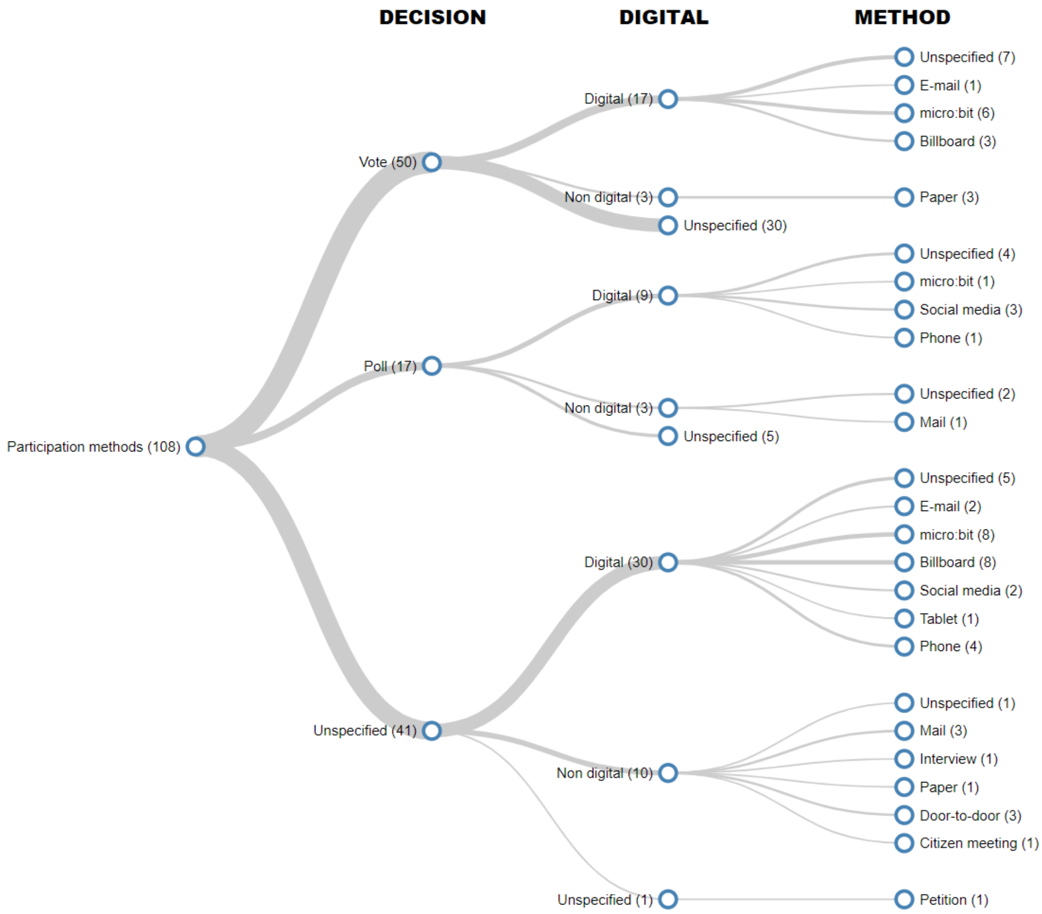

Figure 10. Participation processes proposed by the children. The second, third, and fourth level nodes of the tree are related, respectively, to the *decision*, *digital*, and *method* characteristics. A path in the tree defines a participation process characterized by each node it crosses (n = 114).

3.3. The Workshop as a Participation Activity

The positive and negative points raised by the children are listed in Table 5 for group discussions and in Table 6 for the workshop. Regarding group discussions, 21 (resp. 31) children did not mention any positive (resp. negative) points. Concerning the workshop, 36 (resp. 61) children did not mention any positive (resp. negative) points. Substantially fewer children mentioned negative points for the workshop than for the group discussion, which is an encouraging result.

The main positive and negative points are fairly similar for both group discussions and the workshop. Nonetheless, some discrepancies should be noted. First, the opportunity to learn new things was mentioned twice more frequently for the workshop. Second, the fun characteristics of the workshop were mentioned in several answers. Third, the opportunity to change one’s opinion (or other opinions) and the fact that more ideas were able to emerge were mentioned, respectively, two and three times more for the workshop and, thus, less frequently than for group discussions.

Table 5. Positive and negative points of **group discussions**. The number of times an aspect was raised by the children is noted in parenthesis.

Positive Points	Negative Points
Opportunity to give one's opinion (50)	Disagreements (30)
Opportunity to hear others' opinions (43)	Conflicts (29)
More ideas can emerge (11)	Interruptions (11)
Opportunity to change one's opinion (or other opinions) (9)	Noise (7)
Opportunity to learn new things (7)	Having to wait for one's turn to speak (6)

Table 6. Positive and negative points of the **workshop**. The number of times an aspect was raised by the children is noted in parenthesis.

Positive Points	Negative Points
Opportunity to give one's opinion (22)	Disagreements (15)
Opportunity to learn new things (15)	Non-participation of some classmates (6)
Opportunity to hear other opinions (11)	Stubbornness (5)
It was fun (7)	Influence from others about one's opinion (5)

4. Discussion

4.1. Theoretical Contributions

The workshop presented in this paper contributes to the two previously identified research gaps. Concerning the lack of **innovative participation opportunities for children** in the smart city, the workshop constitutes a solid basis for children to be informed about the concept, to enable their participation, and to allow them to develop smart city solutions themselves. This method could be integrated into the participation ecosystem of a smart city [70] along with other methods. Indeed, we believe the workshop will be complementary to existing participation methods [71]. For instance, within a living lab, an urban innovation ecosystem often encountered in smart cities [72], the workshop could take advantage of the lab infrastructure as well as the expertise of researchers, businesses, and public agents. Another possible complementarity might come from the use of the workshop to facilitate participatory budgeting meetings. Indeed, these meetings can be abstract and complex for citizens and the workshop would provide an interesting, fun, and tangible support to the discussions. Additionally, other complementarities could be found in urban planning meetings [18], e-participation platforms [70,73], or open data portals [74].

Concerning the lack of **initiatives that educate children** about the smart city concept, an analysis of the smart city definitions shows that the workshop was successful in changing the children's initial visions of a smart city toward a more problem-solving and citizen participation-oriented one. The workshop was successful in providing a broader view of the smart city dimensions as well. In the pre-test, definitions almost exclusively covered the environment and mobility as these are areas that children are more familiar with in their daily lives. In the post-test, the examples discussed in Step 1 were reused in the definitions, and some children retained the six dimensions and listed them as definitions. The strong focus of Step 2 and Step 3 on governance also explains the increase of occurrences for this dimension. The focus on citizen participation also shaped the smart city projects proposed by the children, explaining the strong presence of participation-oriented projects. Finally, the workshop was successful in stimulating critical discussions on participation methods. This is well illustrated by the wide diversity of participation processes proposed by the children. This suggests that citizen participation and the means to implement it is a topic that can be discussed with children in their early secondary studies. During the workshop sessions, some children criticized the micro:bit voting solution because technology may introduce an entry barrier to participation; consequently, they proposed alternative or complementary non-digital participation methods.

4.2. Lessons Learned for Practice

We would qualify the 2 × 100 min format as ideal for the proper implementation of the workshop. Indeed, leaving one full session for the programming activity enables answering in-depth questions about the children and discussing the challenges and limitations of smart city solutions. Furthermore, the best evolution of a child's understanding of a smart city concept comes from the classes where this format is used.

The 2 × 50 format also enables dedicating one session to the programming activity. However, capturing a child's attention (regarding interests and concentration efforts) for 50 min was challenging. Furthermore, the discussions were not as deep as with the 2 × 100 min format. We would, therefore, not recommend using this format. The workshop is less-marking; some children who completed the post-test several weeks after the workshop noted that they did not remember the workshop at all.

The 1 × 150 min session was considered too long by the children in terms of concentration efforts. Furthermore, the city model was constructed beforehand by the children for another class. This was detrimental to the quality of the workshop as the city was less realistic than in the other workshops and we were not able to discuss concrete urban issues as easily on that basis. Consequently, the children did not seem as engaged in the programming activity. Starting with the theoretical introduction and debating concrete urban issues is what really enables children to understand the purpose of the smart city solution.

Regarding the 1 × 90 min format, we did not capture information about the children's understanding through questionnaires but we noted that the timing was too short to go in-depth in each step of the workshop. However, several children still showed interest in programming after the presentation of the smart city solutions with micro:bit. Indeed, as expected, programming activity played an important role in making the workshop more enjoyable. Several children who could participate in the programming activity with the other workshop formats explicitly mentioned it as a positive point of the workshop in the post-test questionnaire, and we believe it contributed to the playful character of the workshop. However, the programming activity alone is not sufficient. Due to data collection issues, 21 children participated only in the third step of the workshop and, therefore, completed only the post-test. In their definition of the smart city, 13 of these 21 children mentioned the technological orientation of the smart city. Strikingly, none mentioned anything related to problem-solving, citizen problems, and citizen participation, despite the programming activity consisting of developing a voting system. Regarding participation methods, only 4 out of 21 children proposed one.

On a more general note, two aspects we believe would be essential to work toward are the opportunity to change one's opinion (or others' opinions), and the fact that more ideas are able to emerge. Indeed, they are important positive points of group discussions but they were mentioned on rare occasions for the workshop. One possible explanation is the fact that children were divided into small groups for activities involving group discussions, namely the building of the city model. The model was then constructed by building up the results of these smaller-scale group discussions, with children not immediately given the opportunity to question the choices of groups other than their own during the model construction. Some answers may concern the part when the decisions of the groups are shared to build the model, rather than the discussion that led to these decisions inside each group. Therefore, it is essential to take the necessary time to allow children to debate ideas at all steps of the workshop.

Drawing from these observations, we state the following recommendations:

- The programming activity should be held in a separate session.
- Enough time (75 min would be a minimum) should be dedicated to each session to allow children to discuss the concepts and debate ideas.

- The children should be challenged as much as possible at each step of the workshop. In the theoretical introduction, we asked them about the limitations of the examples of the solutions. During the model construction, we discussed the real-life political process with them. Finally, in the programming part, we challenged their solutions in terms of feasibility, privacy, representativeness, etc.
- Playful character should be kept and stimulated as much as possible during each step of the workshop. Even though it was given to children of different ages, we observed that a playful experience really helps to capture their attention and increase their willingness to learn. The programming activity was useful for stimulating the playful character of the workshop.

4.3. Limitations

Post-tests were completed by the children a few days or weeks after the workshop. In one school, there was an issue that led to 59 children completing the post-test several weeks after the workshop (later than we planned). Overall, we observed a lower quality for these data. All these children participated in the 2 × 50 min workshop. It would, thus, be interesting to determine whether this issue is specific to this format. More generally, it would also have been interesting to assess whether the impact of the workshop persists by administering a third follow-up questionnaire several months after the workshop. This would, however, have been tedious to achieve. We only captured the necessary information to match the pre-test and post-test questionnaires, and the workshops were given during the second semester of the school year. Therefore, several months after the workshops, the children would have started a new school year in a different class, and it would have been impossible to trace them back for a follow-up questionnaire.

The matching of the pre-tests and post-tests was performed for only 130 children out of 299. More specifically, no post-tests were collected for the specialized education type because they all participated in the 1 × 90 min format. As they showed great interest in the hands-on nature of the workshop, particular attention should be set to this audience in the future. Moreover, the quality of the data collected from the 15 children enrolled in a differentiated education program was lower as well. This was expected since we observed that they were much less assiduous while completing the questionnaires. Although more workshop sessions would be needed to confirm this, it suggests that other data collection methods should be used to assess the workshop with this audience. Thus, to generalize the findings to our whole target group, more data would be needed from children in specialized education and children in first and third secondaries, for all education types, possibly involving other data collection methods.

When the in-school sessions of the workshops were organized, recurring themes in the news included climate change and youth mobilization for climate [75]. This appeared to be somewhat reflected in the questionnaire answers, judging by the prominence of the environmental dimension compared to the others. The results of the workshop might have slightly differed in that regard, had the news context been different. However, we cannot precisely assess the impacts on the results.

The material used in the workshop may have impacted the findings in several ways. The unbuilt map was out of scale compared to the buildings children placed on it, which may have caused incorrect perceptions of the distance between the elements of the map. However, this issue was, to some extent, mitigated by the road infrastructure and natural elements displayed on the map that allowed children to understand the size of the area covered by the map. Moreover, the unbuilt map was an abstract plan of an existing Belgian city. It is likely that some children from our sample recognized the city and were familiar with it while others did not. This also may have impacted the conduct of Step 2 as some children could instinctively reproduce the city that they know. No such behavior was observed during the workshop sessions, but these observations were not collected following a robust protocol and the familiarity of children with the represented city was not captured in the data collection. In future work, it would be valuable to study whether the familiarity with the area represented on the map and its size have impacts on the findings. This can be achieved by replicating the workshop with maps representing different cities of different scales.

4.4. Future Work

The workshop proposal and its first results were presented at several conferences and exhibitions and have sparked strong interest among the attendees. Feedback was given by public servants, researchers in citizen participation, digital education experts, and teachers. This feedback from practitioners along with the data collected following the in-school sessions shaped the two avenues for further research that are proposed in the remainder of this section. To address the next steps of our research in a way that best benefits the practice, we plan to keep these practitioners involved.

4.4.1. Improving the Collective Urban Planning Exercise with Tangible Interaction

One limitation of the workshop is that the problems with the city model raised during the second step usually consist of missing or misplaced buildings. Overall, very few issues were raised on the impacts of the placed buildings on their vicinity (e.g., noise, road congestion). At the same time, some practitioners noted that the workshop could be improved if the city model could display information related to the placed buildings and their impacts. To address this issue, we planned to work on a new version of the model construction step by leveraging tangible interaction.

The first motivation for considering tangible interaction is that it is reported in the literature as playful [76,77] and especially suitable for collaborative learning activities [78]. These qualities are important positive points of the workshop that were raised by children in the post-test questionnaire and we are committed to preserving them. In addition, since tangible interaction is especially suited for collaborative work and discussions [78,79], it could add to the opportunity to question one's opinion (or other opinions) and it shows that more ideas emerge when working in a group with the workshop's strengths.

Inspired by the reacTIVision framework [80] and the URP system [81], the envisioned system would take the form of a table into which a city map display would be projected. The buildings would be similar to those used in the current version of the workshop but would be assigned a unique token that could be read once they are placed on the city map. It would allow automatically recognizing the buildings and projecting on the map specific information. Children could then observe how the city map reacts to the buildings and reflect on their decisions to place them.

However, while tangible interaction in the workshop is a promising avenue, it would be detrimental to two convenient aspects of the current workshop, which should be acknowledged. One advantage of the workshop is that it is possible to transport the necessary equipment to any place, which allows us to move from class to class. Naturally, an interactive table is tedious to carry around. Another advantage is the cost of the equipment. In total, the buildings and the city model are expenses under USD 100 and do not require any specific skills to set up. However, the construction of an interactive table as described requires much more resources, time, and technical skills.

4.4.2. Expanding the Workshop for Adult Participation

The workshop introduces the smart city to children and enables their participation within this paradigm. However, children are only a sub-group of the citizenry, and the extension of the workshop to adults is a promising lead for further research. Indeed, throughout the workshop presentations that were given to practitioners, one recurring insight was that the target audience could reach beyond children to adults. One challenge that should be acknowledged is the recruiting of participants. All workshop sessions we organized were in-class activities and, thus, did not raise any participant-recruiting issues as the activities were mandatory to attend for the children. However, as mentioned in [82], there are several motivating factors for citizens to participate in their cities, including the playfulness of the participation experience or the learning opportunities it provides. Therefore, as these two factors were explicitly mentioned by the children when discussing the positive points of the workshop, we are confident that adults would engage in it as well after necessary adaptations, some of which were hinted at through the practitioners' feedback. In the theoretical introduction step, more realistic and complex examples could be presented. The citizen participation concept could also be discussed more in-depth by detailing the different levels of participation that can be implemented [83–85]. In the construction of the model step, more realistic budget constraints could be imposed. Through a collaboration with public servants, scenarios based on real-life cases (e.g., the opening of a mall in the center of a city) could be used to structure the discussions and output more concrete results. Additionally, more advanced roles could be assigned in the group discussions to reflect the roles and structures of a municipal council. In the solution step, more advanced techniques, such as end-user programming [86], could be used to design smart city solutions with the adults.

5. Conclusions

In this paper, we address two issues. First, the smart city concept, although recurrent in political discourses, scientific literature, and news, remains obscure to the larger public, who, thus, fail to feel involved. However, citizen participation has been advocated in research studies (and more recently in practice) as it is critical to the success of a smart city. Therefore, it is necessary to educate citizens about this concept, its ins and outs, and the roles they play within. Second, although many participation methods are implemented, some citizenry groups are still left behind. One of these groups is children, whose participation in public issues has nevertheless been repeatedly recommended by UNICEF and in several research fields.

As a solution, we present a workshop that introduces the smart city concept to children; it can serve as a participation method for this audience. The workshop, built following the design science methodology, consists of (1) a discussion around the six smart city dimensions illustrated with real-life examples, (2) the collective urban planning exercise resulting in a city model that serves as work support and the identification of issues in the built mock city and of methods for asking citizens' opinions on these issues, and (3) the development of a voting system using a novice-level programming interface. The workshop was tested as an in-class activity with 299 children from several different schools.

When feasible, data about children's understanding of the smart city and their views on citizen participation methods were collected via a questionnaire completed before and after the workshop following a pre-test–post-test design. In total, 130 questionnaire pairs were collected and analyzed. Regarding the education of the smart city concept, the results show that the workshop was successful in shifting the children's vision of a smart city from being solely technological to a vision where technology is at the service of citizens and is useful at solving issues they face daily. During the sessions, children showed enthusiasm toward the proposed activities and critical thinking, especially when discussing participation methods. This shows that smart cities and citizen participation are concepts that can be discussed in a meaningful way with children between the ages of 12 and 14. The workshop also shows potential as a participation method; children noted that it was fun and a good opportunity to share one's opinion (and hear other opinions). We also discussed how the workshop can be combined with existing participation methods, such as living labs and budgeting meetings.

The data collected during the evaluation of the workshop, its observed limitations, as well as the feedback provided by multiple practitioners allowed us to propose avenues for future research. In particular, we plan to study how tangible interactions can help support the construction of the city model and to work on an adapted version of the workshop suitable for adult participation. In engaging in these avenues, we plan to work closely with multiple practitioners to conduct our research in a way that best benefits practice.

Author Contributions: Conceptualization, A.C., A.S. and J.H.; methodology, A.C., A.S. and J.H.; software, A.C. and A.S.; validation, A.C. and A.S.; formal analysis, A.C. and A.S.; investigation, A.C. and A.S.; resources, J.H.; data curation, A.C. and A.S.; writing—original draft preparation, A.C. and A.S.; writing—review and editing, A.C., A.S., J.H., B.V. and B.D.; visualization, A.C.; supervision, J.H. and B.D.; project administration, B.V. and B.D.; funding acquisition, J.H., B.V. and B.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the European Regional Development Fund (ERDF) grant number [ETR121200003138].

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data sharing not applicable.

Acknowledgments: Our gratitude goes to the teachers who kindly hosted the workshop sessions in their classes. We also thank our colleague Anne Smal for her help in the design of the workshop.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. United Nations. *World's Population Increasingly Urban with More Than Half Living in Urban Areas*; Technical Report; United Nations: New York, NY, USA, 2014. Available online: http://www.un.org/en/development/desa/news/population/world-urbanization-prospects-2014.html (accessed on 22 January 2019).
2. Huang-Lachmann, J.T. Systematic Review of Smart Cities and Climate Change Adaptation. *Sustain. Account. Manag. Policy J.* **2019**, *10*, 745–772. [CrossRef]
3. Javed, A.R.; Shahzad, F.; ur Rehman, S.; Zikria, Y.B.; Razzak, I.; Jalil, Z.; Xu, G. Future smart cities requirements, emerging technologies, applications, challenges, and future aspects. *Cities* **2022**, *129*, 103794. [CrossRef]
4. Harrison, C.; Donnelly, I. A Theory of Smart Cities. In Proceedings of the Annual Meeting of the ISSS, Hull, UK, 17–22 April 2011; International Society for the Systems Sciences: Nashville, TN, USA, 2011.
5. Perera, C.; Zaslavsky, A.; Christen, P.; Georgakopoulos, D. Sensing as a Service Model for Smart Cities Supported by Internet of Things. *Trans. Emerg. Telecommun. Technol.* **2014**, *25*, 81–93. [CrossRef]
6. Dameri, R. Comparing Smart and Digital City: Initiatives and Strategies in Amsterdam and Genoa. Are They Digital and/or Smart? In *Smart City*; Dameri, R., Rosenthal-Sabroux, C., Eds.; Springer: Cham, Switzerland, 2014; pp. 45–88.
7. Hollands, R. Will the Real Smart City Please Stand Up? Intelligent, Progressive or Entrepreneurial? *City* **2008**, *12*, 303–320. [CrossRef]
8. Allam, Z.; Sharifi, A.; Bibri, S.E.; Chabaud, D. Emerging Trends and Knowledge Structures of Smart Urban Governance. *Sustainability* **2022**, *14*, 5275. [CrossRef]
9. Esposito, G.; Clement, J.; Mora, L.; Crutzen, N. One size does not fit all: Framing smart city policy narratives within regional socio-economic contexts in Brussels and Wallonia. *Cities* **2021**, *118*, 103329. [CrossRef]
10. El Hilali, S.; Azougagh, A. A netnographic research on citizen's perception of a future smart city. *Cities* **2021**, *115*, 103233. [CrossRef]
11. Kopackova, H.; Komarkova, J.; Horak, O. Enhancing the diffusion of e-participation tools in smart cities. *Cities* **2022**, *125*, 103640. [CrossRef]
12. Kitchin, R. The Real-Time City? Big Data and Smart Urbanism. *GeoJournal* **2014**, *79*, 1–14. [CrossRef]
13. Cugurullo, F. How to Build a Sandcastle: An Analysis of the Genesis and Development of Masdar City. *J. Urban Technol.* **2013**, *20*, 23–37. [CrossRef]
14. Caragliu, A.; Del Bo, C.; Nijkamp, P. Smart Cities in Europe. *J. Urban Technol.* **2011**, *18*, 65–82. [CrossRef]
15. Chourabi, H.; Nam, T.; Walker, S.; Gil-Garcia, J.; Mellouli, S.; Nahon, K.; Pardo, T.; Scholl, H. Understanding Smart Cities: An Integrative Framework. In Proceedings of the Hawaii International Conference on System Sciences, Maui, HI, USA, 4–7 January 2012; Institute of Electrical and Electronics Engineers: New York, NY, USA, 2012; pp. 2289–2297.
16. Hart, R. Children's Participation: From Tokenism to Citizenship. *Innocenti Essay* **1992**, *4*, 1–41.
17. Hart, J. Children's Participation and International Development: Attending to the Political. *Int. J. Child. Rights* **2008**, *16*, 407–418. [CrossRef]
18. Hennig, S. Smart Cities Need Smart Citizens, but What About Smart Children? In Proceedings of the International Conference on Urban Planning, Regional Development and Information Society, Vienna, Austria, 21–23 May 2014; Competence Center of Urban and Regional Planning: Vienna, Austria, 2014; pp. 553–561.
19. Cámara, A.M.N.; i Torres, F.C.; Porto, H.P. Meetings Between Professionals for the Inclusion of Children in Citizen Participation: A Formative Experience. *Soc. Incl.* **2022**, *10*, 19–31.
20. Chawla, L. Evaluating children's participation: Seeking areas of consensus. *PLA Notes* **2001**, *42*, 9–13.

21. Checkoway, B. What is Youth Participation? *Childr. Youth Serv. Rev.* **2011**, *33*, 340–345. [CrossRef]
22. Riggio, E. Child Friendly Cities: Good Governance in the Best Interests of the Child. *Environ. Urban.* **2002**, *14*, 45–58. [CrossRef]
23. van der Graaf, S. The Right to the City in the Platform Age: Child-Friendly City and Smart City Premises in Contention. *Information* **2020**, *11*, 285. [CrossRef]
24. Mansfield, R.G.; Batagol, B.; Raven, R. "Critical agents of change?": Opportunities and limits to children's participation in urban planning. *J. Plan. Lit.* **2021**, *36*, 170–186. [CrossRef]
25. Garau, C.; Annunziata, A. Smart City Governance and Children's Agency: An Assessment of the Green Infrastructure Impact on Children's Activities in Cagliari (Italy) with the Tool 'Opportunities for Children in Urban Spaces (OCUS)'. *Sustainability* **2019**, *11*, 4848. [CrossRef]
26. Rehm, M.; Jensen, M.; Wøldike, N.; Vasilarou, D.; Stan, C. Smart Cities for Smart Children. In Proceedings of the Smart City Learning, Graz, Austria, 16–17 August 2014.
27. Hosio, S.; Kostakos, V.; Kukka, H.; Jurmu, M.; Riekki, J.; Ojala, T. From School Food to Skate Parks in a Few Clicks: Using Public Displays to Bootstrap Civic Engagement of the Young. In Proceedings of the International Conference on Pervasive Computing, Newcastle, UK, 18–22 June 2012; Springer: Cham, Switzerland, 2012; pp. 425–442.
28. Donert, K.; de Miguel González, R.; Luppi, A. YouthMetre: Open Data to Empower Young People to Engage in Democracy and Policy-Making. In *Geospatial Technologies in Geography Education*; de Miguel González, R., Donert, K., Koutsopoulos, K., Eds.; Springer: Cham, Switzerland, 2019; pp. 87–101.
29. Simpson, B. Towards the participation of children and young people in urban planning and design. *Urban Stud.* **1997**, *34*, 907–925. [CrossRef]
30. de Andrade, B.; Poplin, A.; Sousa de Sena, Í. Minecraft as a tool for engaging children in urban planning: A Case study in Tirol Town, Brazil. *ISPRS Int. J. Geo-Inf.* **2020**, *9*, 170. [CrossRef]
31. Peacock, S.; Anderson, R.; Crivellaro, C. Streets for people: Engaging children in placemaking through a socio-technical process. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Montréal, QC, Canada, 21–26 April 2018; Association for Computing Machinery: New York, NY, USA, 2018; pp. 1–14.
32. Simonofski, A.; Asensio, E.; De Smedt, J.; Snoeck, M. Citizen Participation in Smart Cities: Evaluation Framework Proposal. In Proceedings of the Conference on Business Informatics, Thessaloniki, Greece, 24–27 July 2017; Institute of Electrical and Electronics Engineers: New York, NY, USA, 2017; Volume 1, pp. 227–236.
33. Pallot, M.; Trousse, B.; Senach, B.; Scapin, D. Living Lab Research Landscape: From User Centred Design and User Experience towards User Cocreation. In Proceedings of the European Summer School of Living Labs, Paris, France, 25–27 August 2010; European Network of Living Labs: Saint-Josse-ten-Noode, Belgium, 2010.
34. Aham-Anyanwu, N.; Li, H. Toward E-Public Engagement: A Review of Public Participation for Government Governance. In Proceedings of the International Conference on Information Systems, Fort Worth, TX, USA, 13–16 December 2015; Association for Information Systems: Atlanta, GA, USA, 2015.
35. Simonofski, A.; Amaral de Sousa, V.; Clarinval, A.; Vanderose, B. Participation in Hackathons: A Multi-Methods View on Motivators, Demotivators and Citizen Participation. In Proceedings of the International Conference on Research Challenges in Information Science, Limassol, Cyprus, 22–25 September 2020; Springer: Cham, Switzerland, 2020.
36. Hanssen, G.S. The social sustainable city: How to involve children in designing and planning for urban childhoods? *Urban Plan.* **2019**, *4*, 53–66. [CrossRef]
37. Edelmann, N.; Krimmer, R.; Parycek, P. Engaging youth through deliberative e-participation: A case study. *Int. J. Electron. Gov.* **2008**, *1*, 385–399. [CrossRef]
38. Piser, M.; Wöllmann, S.; Zink, R. Adolescents in Spatial Planning–A Digital Participation Platform for Smart Environmental and Democratic Education in Schools. *J. Digit. Landsc. Archit.* **2020**, *5*, 584–591.
39. Simonofski, A.; Dumas, B.; Clarinval, A. Engaging Children in the Smart City: A Participatory Design Workshop. In Proceedings of the SIGSOFT International Workshop on Education through Advanced Software Engineering and Artificial Intelligence, Tallinn, Estonia, 26 August 2019; Association for Computing Machinery: New York, NY, USA, 2019; pp. 1–4.
40. Hargittai, E.; Walejko, G. The Participation Divide: Content Creation and Sharing in the Digital Age. *Inf. Community Soc.* **2008**, *11*, 239–256. [CrossRef]
41. Hennig, S.; Vogler, R.; Gryl, I. Spatial Education for Different User Groups as a Prerequisite for Creating a Spatially Enabled Society and Leveraging SDI. *Int. J. Spat. Data Infrastruct. Res.* **2013**, *8*, 98–127.
42. Gryl, I.; Jekel, T. Re-Centring Geoinformation in Secondary Education: Toward a Spatial Citizenship Approach. *Cartogr. Int. J. Geogr. Inf. Geovis.* **2012**, *47*, 18–28. [CrossRef]
43. Gryl, I. A Starting Point: Children as Spatial Citizens. *J. Geogr. Inf. Sci.* **2015**, *1*, 241–250. [CrossRef]
44. Giffinger, R.; Gudrun, H. Smart Cities Ranking: An Effective Instrument for the Positioning of the Cities? *Archit. City Environ.* **2010**, *4*, 7–26. [CrossRef]
45. Nam, T.; Pardo, T. Conceptualizing Smart City with Dimensions of Technology, People, and Institutions. In Proceedings of the Annual International Digital Government Research Conference, College Park, MD, USA, 12–15 June 2011; Association for Computing Machinery: New York, NY, USA, 2011; pp. 282–291.
46. Washburn, D.; Sindhu, U.; Balaouras, S.; Dines, R.; Hayes, N.; Nelson, L. Helping CIOs Understand 'Smart City' Initiatives. *Growth* **2009**, *17*, 1–17.

47. Lombardi, P.; Giordano, S.; Farouh, H.; Yousef, W. Modelling the Smart City Performance. *Innov. Eur. J. Soc. Sci. Res.* **2012**, *25*, 137–149. [CrossRef]
48. Mahizhnan, A. Smart Cities: The Singapore Case. *Cities* **1999**, *16*, 13–18. [CrossRef]
49. Neirotti, P.; De Marco, A.; Cagliano, A.; Mangano, G.; Scorrano, F. Current Trends in Smart City Initiatives: Some Stylised Facts. *Cities* **2014**, *38*, 25–36. [CrossRef]
50. Albino, V.; Berardi, U.; Dangelico, R. Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *J. Urban Technol.* **2015**, *22*, 3–21. [CrossRef]
51. Basu, I. Elite Discourse Coalitions and the Governance of 'Smart Spaces': Politics, Power and Privilege in India's Smart Cities Mission. *Polit. Geogr.* **2019**, *68*, 77–85. [CrossRef]
52. Malek, J.A.; Lim, S.B.; Yigitcanlar, T. Social inclusion indicators for building citizen-centric smart cities: A systematic literature review. *Sustainability* **2021**, *13*, 376. [CrossRef]
53. Sontiwanich, P.; Boonchai, C.; Beeton, R.J. An Unsustainable Smart City: Lessons from Uneven Citizen Education and Engagement in Thailand. *Sustainability* **2022**, *14*, 13315. [CrossRef]
54. Pellegrino, M.A.; Roumelioti, E.; D'Angelo, M.; Gennari, R. Children's Participation in the Design of Smart Solutions: A Literature Review. *Smart Cities* **2022**, *5*, 475–495. [CrossRef]
55. Pellegrino, M.A.; Roumelioti, E.; Gennari, R.; D'Angelo, M. Smart City Design as a 21st Century Skill. In Proceedings of the International Conference in Methodologies and intelligent Systems for Techhnology Enhanced Learning, Salamanca, Spain, 6–8 October 2021; Springer: Cham, Switzerland, 2021; pp. 271–280.
56. Von Alan, R.; March, S.; Park, J.; Ram, S. Design Science in Information Systems Research. *MIS Q.* **2004**, *28*, 75–105.
57. Hennig, S.; Vogler, R. User-Centred Map Applications Through Participatory Design: Experiences Gained During the 'YouthMap 5020' Project. *Cartogr. J.* **2016**, *53*, 213–229. [CrossRef]
58. Fails, J.; Guha, M.; Druin, A. Methods and Techniques for Involving Children in the Design of New Technology for Children. *Found. Trends Hum.—Comput. Interact.* **2013**, *6*, 85–166. [CrossRef]
59. Jungk, R.; Müllert, N. *Future Workshops: How to Create Desirable Futures*; Institute for Social Inventions: London, UK, 1987.
60. Lindquist, E. *Design and Analysis of Experiments in Psychology and Education*; Houghton Mifflin: Oxford, UK, 1953.
61. Cobb, P.; Confrey, J.; DiSessa, A.; Lehrer, R.; Schauble, L. Design Experiments in Educational Research. *Educ. Res.* **2003**, *32*, 9–13. [CrossRef]
62. Creswell, J. *Educational Research: Planning, Conducting, and Evaluating*; W. Ross MacDonald School Resource Services Library: Brantford, ON, Canada, 2013.
63. Zimmermann, H.D. Youth e-participation: Lessons learned from an ongoing project in Switzerland. In Proceedings of the Bled eConference, Bled, Slovenia, 19–22 June 2016; pp. 1–9.
64. Hennig, S. Child-and Youth-Friendly Cities: How Does and Can Crowdmapping Support Their Development? A Case Study Using OpenStreetMap in the Austrian City of Salzburg. *Artic.-J. Urban Res.* **2019**. Available online: https://journals.openedition.org/articulo/4296 (accessed on 12 November 2020).
65. Grieve, A. Pretest-Posttests Designs. *Am. Stat.* **1981**, *35*, 177–178.
66. Dimitrov, D.; Rumrill, P., Jr. Pretest-Posttest Designs and Measurement of Change. *Work* **2003**, *20*, 159–165. [PubMed]
67. Saldaña, J. *The Coding Manual for Qualitative Researchers*; Sage: London, UK, 2015.
68. Boynton, P.; Greenhalgh, T. Selecting, Designing, and Developing Your Questionnaire. *Br. Med. J.* **2004**, *328*, 1312–1315. [CrossRef]
69. Weber, R. *Basic Content Analysis*; Number 49; Sage: London, UK, 1990.
70. Berntzen, L.; Johannessen, M.R. The Role of Citizen Participation in Municipal Smart City Projects: Lessons Learned from Norway. In *Smarter as the New Urban Agenda*; Gil-Garcia, R.J., Pardo, T., Nam, T., Eds.; Springer: New York, NY, USA, 2016; pp. 299–314.
71. Krommyda, V.; Somarakis, G.; Stratigea, A. Integrating Offline and Online Participation Tools for Engaging Citizens in Public Space Management: Application in the Peripheral Town of Karditsa-Greece. *Int. J. Electron. Gov.* **2019**, *11*, 89–115. [CrossRef]
72. Cossetta, A.; Palumbo, M. The Co-Production of Social Innovation: The Case of Living Lab. In *Smart City*; Dameri, R., Rosenthal-Sabroux, C., Eds.; Springer: Cham, Switzerland, 2014; pp. 221–235.
73. Kim, B.; Yoo, M.; Park, K.C.; Lee, K.R.; Kim, J.H. A value of civic voices for smart city: A big data analysis of civic queries posed by Seoul citizens. *Cities* **2021**, *108*, 102941. [CrossRef]
74. Atenas, J.; Havemann, L. *Open Data as Open Educational Resources: Case Studies of Emerging Practice*; Open Knowledge—Open Education Working Group: London, UK, 2015.
75. Napawan, N.; Simpson, S.A.; Snyder, B. Engaging Youth in Climate Resilience Planning with Social Media: Lessons from #OurChangingClimate. *Urban Plan.* **2017**, *2*, 51–63.
76. Hornecker, E.; Buur, J. Getting a Grip on Tangible Interaction: A Framework on Physical Space and Social Interaction. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Montréal, QC, Canada, 22–27 April 2006; Association for Computing Machinery: New York, NY, USA, 2006; pp. 437–446.
77. Marshall, P. Do Tangible Interfaces Enhance Learning? In Proceedings of the International Conference on Tangible and Embedded Interaction, Baton Rouge, LA, USA, 15–17 February 2007; Association for Computing Machinery: New York, NY, USA, 2007; pp. 163–170.
78. Horn, M.; Crouser, R.; Bers, M. Tangible Interaction and Learning: The Case for a Hybrid Approach. *Pers. Ubiquitous Comput.* **2012**, *16*, 379–389. [CrossRef]

79. Schneider, B.; Jermann, P.; Zufferey, G.; Dillenbourg, P. Benefits of a Tangible Interface for Collaborative Learning and Interaction. *Inst. Electr. Electron. Eng. Trans. Learn. Technol.* **2010**, *4*, 222–232. [CrossRef]
80. Kaltenbrunner, M.; Bencina, R. reacTIVision: A Computer-Vision Framework for Table-Based Tangible Interaction. In Proceedings of the International Conference on Tangible and Embedded Interaction, Baton Rouge, LA, USA, 15–17 February 2007; Association for Computing Machinery: New York, NY, USA, 2007; pp. 69–74.
81. Underkoffler, J.; Ishii, H. URP: A Luminous-Tangible Workbench for Urban Planning and Design. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Pittsburgh, PA, USA, 15–20 May 1999; Association for Computing Machinery: New York, NY, USA, 1999; pp. 386–393.
82. Wijnhoven, F.; Ehrenhard, M.; Kuhn, J. Open Government Objectives and Participation Motivations. *Gov. Inf. Q.* **2015**, *32*, 30–42. [CrossRef]
83. Arnstein, S. A Ladder of Citizen Participation. *J. Am. Inst. Plan.* **1969**, *35*, 216–224. [CrossRef]
84. International Association for Public Participation. *Public Participation Spectrum*; Technical Report; International Association for Public Participation: Denver, CO, USA, 2018. Available online: https://cdn.ymaws.com/www.iap2.org/resource/resmgr/pillars/Spectrum_8.5x11_Print.pdf (accessed on 13 November 2020).
85. Cardullo, P.; Kitchin, R. Being a 'Citizen' in the Smart City: Up and Down the Scaffold of Smart Citizen Participation in Dublin, Ireland. *GeoJournal* **2019**, *84*, 1–13. [CrossRef]
86. Lieberman, H.; Paternò, F.; Klann, M.; Wulf, V. End-User Development: An Emerging Paradigm. In *End User Development*; Lieberman, H., Paternò, F., Wulf, V., Eds.; Springer: New York, NY, USA, 2006; pp. 1–8.