Research on the Playability of Urban Programming Blocks: A Case Study with Users Aged 6-12

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Abstract. ‘Urban Programming Blocks’ is an architectural programming tool in an urban context, explicitly designed for children aged 6 to 12. Its purpose is to popularize urban compositional logic and urban planning principles through intuitive expression and interactive teaching methods, for stimulating children’s spatial imagination and creativity. The playability of the Urban Programming Blocks lies in the diversity of module combinations. As a teaching aid, they have both tangible visual characteristics and abstract representation on spatial information,which were well aligned with the cognitive development of children aged 6 to 12. The Urban Programming Blocks hint the knowledge from spatial perception to intelligent decision-making. Research into their playability contributes to enhancing the quality of urban spatial knowledge teaching for this age group.

Keywords: Urban Programming; Playability; Spatial Teaching Aid; Urban Spatial Education

1 Introduction

The concept of architectural programming and its associated tools, initially proposed and put into practice by William Peña1[1] in 1950, have undergone substantial development and innovation, evolving into a highly effective mode of communication in the field of spatial design. The core of architectural programming is the abstraction and visualization of spatial information, representing humanistic spatial characteristics through certain physical entities. This allows spatial information to be manipulated, displayed, and computationally analyzed [1]. Leveraging the project team’s experience in urban planning, the concept of architectural programming was applied to the urban

[1] In 1959, William Pena and William Caudill published an article titled *Architectural Analysis: A Commencement of Good Design* in the journal *Architectural Record*, which is considered one of the earliest propositions of architectural programming concepts.

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scale along with urban morphology[2], for replacing the original architectural function with the urban function. In this context, a set of Urban Programming Blocks was developed. As the urban renewal is under processing all over China, there have been increasing children-friendly spaces within urban plans, enabling children to make more cultural interaction with the interface of the cities. However, there is a lack of popularization in children's early education regarding urban compositional logic and urban planning principles. Therefore, the initial intention of the design of Urban Programming Blocks was to allow children to simulate small-scale urban planning by building and combining these blocks. This process serves to educate them on the principles of urban composition and foster an interest in spatial design. Based on the previous studies about the age at which spatial cognition is initiated, and the considerations of the physical characteristics and curriculum features of the blocks[2], the research team conducted urban planning-related knowledge dissemination among selected primary school children aged 6 to 12. The application of Urban Programming Blocks was recorded through questionnaires, on-site videos, outcome comparisons and other methods. This information was then analysed and compared to identify current challenges and future optimizing directions. This paper aims to synthesize the design logic behind the playability of Urban Programming Blocks and elucidate critical areas of focus to guide the future design of similar urban science educational tools.

2 Current Status of Urban Blocks

2.1 As Spatial Planning Tools

The working principle of architectural programming and its tools involves the abstraction of spatial information to make it operable. Processing information such as textual descriptions, colour coding, and graphics that carry distinctive visual characteristics makes the concretization of information more convenient [3]. During the development of architectural programming, enhancing the communicative capacity of planning tools to facilitate effective adjustments in target space design has been a core technological objective. In the United States, the birthplace of architectural programming, students are required to "understand the application of typical media carriers, including freehand representation and computer technology, to express essential elements of planning and design phases.", which highlights the importance of spatial planning tools in design education innovation [4].

Since the 1980s, domestic architectural institutions in China have started to attach importance to training in space and form, specifically the study of spatial typology. Starting in 1996, the team led by Professor Gu Daqing at the Chinese University of Hong Kong has conducted teaching practices, exploring space typologies that align

[2] The theory of urban spatial structure, which lately developed as urban morphology was originating in the western countries. It elucidates the general principles of urban land use and functional zoning. It holds positive instructive significance for urban planning and construction in China.

with Chinese architectural characteristics. They have provided students with methods for using spatial planning tools from a practical perspective. Around 2000, inspired by the achievements of Professor Gu and his team, numerous institutions initiated teaching practices based on training in spatial operations. By 2010, architectural training based on spatial form composition, graphic representation, and physical tool manipulation had gained recognition across various institutions and become a focal point in the first-year architectural curriculum [5]. It can be concluded that, as an auxiliary tool for spatial design, entity blocks have found relatively widespread applications in architectural design and urban planning activities, along with a significant theoretical foundation for product development and a history of evolution.

2.2 As Urban Spatial Education Tools

In the current Chinese compulsory education curriculum, most spatial-related teaching is derived from mathematics courses in primary school and physics courses in middle school. These curriculums primarily focus on the study of the physical properties of space, while the comprehensive learning of human-related spatial knowledgesuch as the foundational aspects of urban composition and planning principles, typically only becomes available at the undergraduate level, following the selection of relevant majors. Due to the influence of the education system, spatial education for 6-12-year-old children in China is relatively rare in arts and humanities courses. Nevertheless, in the previous research analyzing the developmental characteristics of school-age children in spatial cognition, it has been found that children aged 3-7, before starting school, may not engage in reverse thinking temporarily. They mainly rely on perceptual understanding to recognize things, rather than using rational thinking [6]. In other words, learning spatial knowledge for younger children depends more on physical teaching aids and their association with human-defined concepts. However, present spatial knowledge education relies heavily on textbooks, with low levels of visualization and tangibility, making it less suitable for the scientific education of younger school-age children.

Therefore, the teaching aids needs allowing children to gain the perception of spatial characteristics in the interaction, and transform the abstract and difficult words into concrete things that can be touched in another form [7]. Physical teaching aids with urban themes have not yet played a important role.

2.3 As a Tool for Cognitive Development

Children's spatial cognitive abilities do not develop autonomously but are primarily influenced by the environment in which they grow, the thinking triggered by hands-on tool usage, as well as communication and interaction with parents and teachers. Some of these abilities require learning to master [8], [9]. The fundamental principle behind architectural space involves the combination of one or more functional entities [10], [11], and the logical composition of a city is similar yet more intricate. This process of producing different outcomes through the diverse combination of information is also the foundational logic of computer programming tasks. Taking LEGO as an example, it allows for the development of thinking through the creation of diverse spatial configurations based on simple modules and the assignment of corresponding spatial definitions. In recent years, numerous manufacturers of building blocks have successively introduced educational tools with a city theme. When it comes to spatial teaching tools, a clear distinction arises between those intended for enlightenment and those designed for practical application. Educational toys aimed at nurturing the intellectual development of preschool children, such as LEGO and building blocks, primarily adhere to a "follow the instructions" style of play. Due to the young age of the players, they find it challenging to engage in more expansive design. On the other hand, other spatial building blocks are primarily used for commercial purposes, such as tangible sandbox models and robotic building blocks with complex motion paths. These are intended for older audiences with a higher knowledge threshold. Apart from these two categories, educational tools for cognitive development, particularly those focused on urban knowledge, are relatively scarce.

3 Playability Considerations in Urban Programming Block Design

3.1 Simulating performance

One of the critical aspects of playability is simulation and emulation. Similar spatial forms can visually trigger children's familiarity with urban spatial memories, encouraging them to participate in planning activities with a sense of ownership. A city model with a similar spatial structure can evoke psychological sensations akin to real spaces [12]. The purpose of urban programming blocks is to provide a more intuitive urban knowledge education to child audiences in coordination with relevant thematic curricula. Playability designs based on simulation enhance the communicative and organizational capabilities of urban programming blocks, allowing child users to better absorb knowledge and achieve the goal of urban information dissemination.

3.2 Intelligence

Another significant characteristic of urban programming blocks is to stimulate players' spatial imagination and creativity, which is a focal point in their playability design. The abstract nature of the modules implies their potential for editing and manipulation, making it possible to educate players of different age groups in urban knowledge, popularize urban constituent elements, and foster children's practical skills and aesthetic sensibility. Modular design allows for multiple possibilities in block combinations, classified and graded by difficulty level. In theory, this can generate a sufficient number of combinations for players to explore, continuously aligning with relevant urban functional definitions, facilitating the development of new urban educational tools and curricula.

3.3 Expressiveness

Playability is not solely reflected in the diversity of combinations but also in the variety of expressions. The term “playability” implies that there are various ways to engage in playing. Urban Programming Blocks, being a tangible visualization tool based on urban information, provide users with insights into their design preferences. [13] These results can be transformed into three-dimensional digital twins and diagrams, enhancing their capacity to interface with information technology tools. This, in turn, broadens their potential for diverse expressions from a playability perspective, offering Urban Programming Blocks a more expansive scope for development and a more comprehensive range of usage scenarios.

4 Curriculum Examples

4.1 Course Format

The team's testing course, titled “Little Community Planners,” recruits children aged 6-12 and can accommodate up to 18 participants. It is conducted at three different locations, with each session lasting within 2 hours and 30 minutes. The curriculum includes urban knowledge dissemination and urban programming block operations. The educational objectives are adjusted based on the age groups of the children in attendance. As illustrated in Figure 1, the course begins with the initial 30 minutes, during which the teacher employs urban knowledge presentations featuring simple and easily understandable cartoon images. This segment is focused on explaining the elements of urban composition and planning logic, guiding children to understand the constituents of our community. The second phase of the course is divided into two parts: 2D block operations and 3D block operations. Children will utilize urban programming blocks to design community spaces. The initial 20 minutes are dedicated to explaining the rules of block operations, followed by 30 minutes of hands-on 3D block operations and 30 minutes of sticker-type block operations. In the final 20-30 minutes, children take turns presenting their design concepts, including their spatial definitions and the urban elements used in their creations. Older participants have the option to use programming software for digital simulations of the blocks to assist in decision-making and propose viable community space design schemes, which have never been incorporated in previous practical sessions.

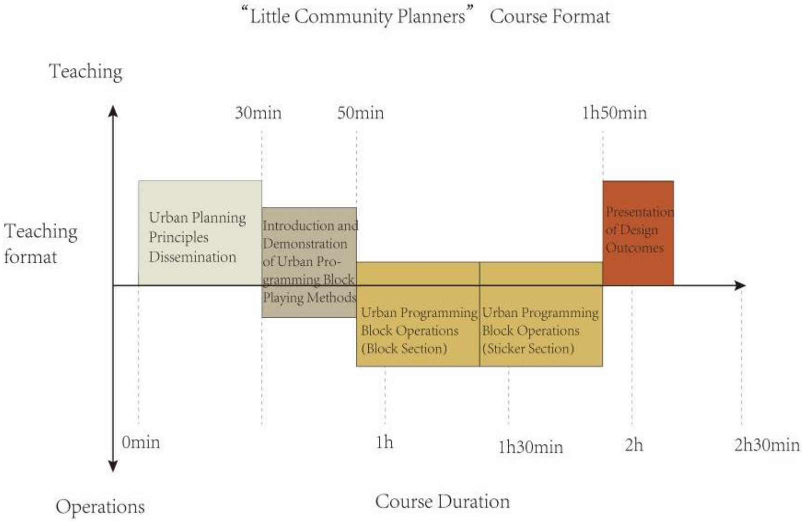

Fig. 1. “Little Community Planners” Course Format

Figure Source: Created by the author based on the course structure

4.2 Teaching Aids

4.2.1 Urban Blocks.

This course mainly uses two kinds of teaching aids, one is urban blocks, the other is embodied blocks. Urban Programming Blocks are tangible tools with the ability to express urban information. It consists of three sizes of modules: large, medium, and small, representing different scales of urban units, as shown in Figure 2. Coupled with urban themes, they encourage children to physically build their local environments, imitating real planning processes and logic. Users can simulate the existing conditions of a selected area using large and medium-sized elements as the urban base and design an ideal community scene using a certain number of small elements. Apart from distinguishing different urban functions using colors, the kit also includes related stickers, magnetic tiles, and other decorations to assist players in creating vivid design displays, as shown in Figure 3. Among them, small elements are the most flexible, distinguished into categories like landscape, architectural structures, information display, open space and facilities. Players can generate various community space models by arranging different elements, theoretically resulting in over 60,000 different combinations, as shown in Figure 4.

The blocks are designed to cater to different age groups, such as building from images for 3-6 year-olds, free designing for 6-12 year-olds, and programming assistance for those aged 12 and above.

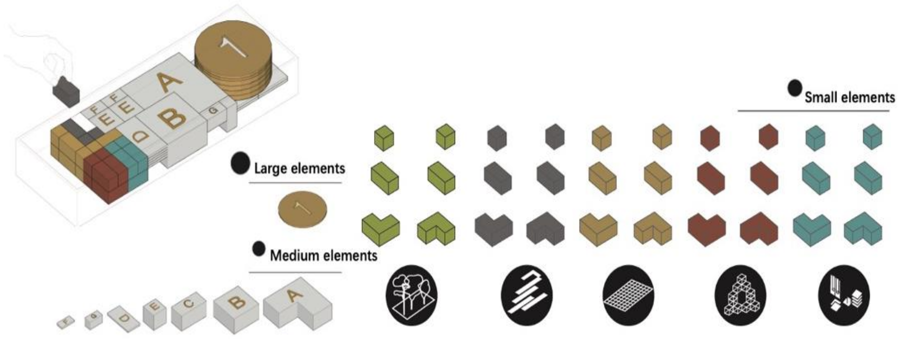

Fig. 2. Main Elements of the Urban Blocks

Figure Source: Created by the author based on the Block Instruction

Fig. 3. Community Space design by Student using Urban Programming Blocks

Figure Source: Photo by taken by the Author

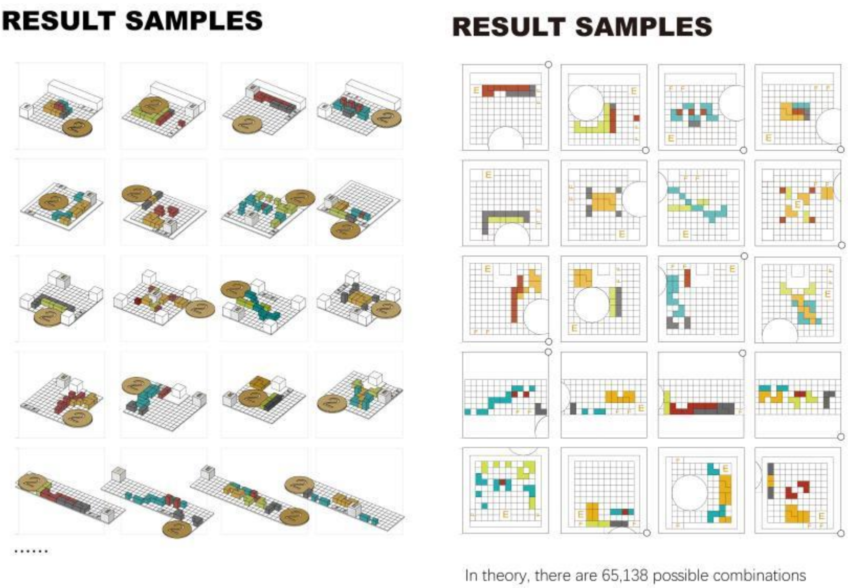

Fig. 4. Diagram of Potential Combinations Using Urban Blocks

Image Source: Created by the author based on the block design manual

4.2.2 Embodiment Blocks.

Embodiment blocks take classroom teaching or social science education activities as the main application scenario. The blocks are composed of four types of cardboard with a height of 1.2 meters,which can be inserted into each other to create an abstract space type,as shown in Figure 5 and Figure 6. The embodiment blocks are made of environmentally friendly honeycomb panels[3]. They can be used to define and express space with the help of materials such as graphic stickers ,as shown in Figure 7. Embodiment blocks aimed to use large-scale teaching AIDS to guide students on creating space that can "play" by themselves. This embodied construction activities in theory will help them on understanding urban space better. The built Spaces can also be linked and combined to produce more complex spatial relationships. Students could realise the abstract space types through the interaction between the body and the environment, so as to achieve the educational purpose.

3 Honeycomb panel is a panel made of two thin panels firmly bonded on both sides of a layer of thicker honeycomb core material, also known as honeycomb sandwich structure. It is light in weight, has strong pressure resistance, which can be recycled after use, so it has the characteristics of no pollution and environmental protection. It is one of the safe materials suitable for children to build space.

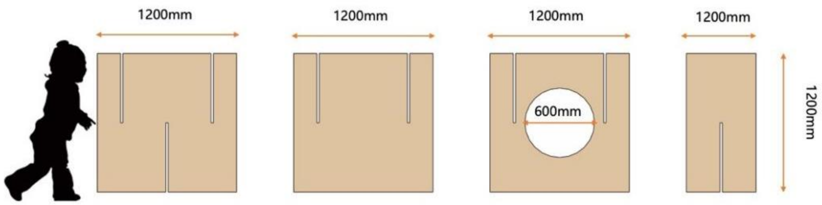

Fig. 5. Main Elements of the Embodiment Blocks

Figure Source: Drawn by the author

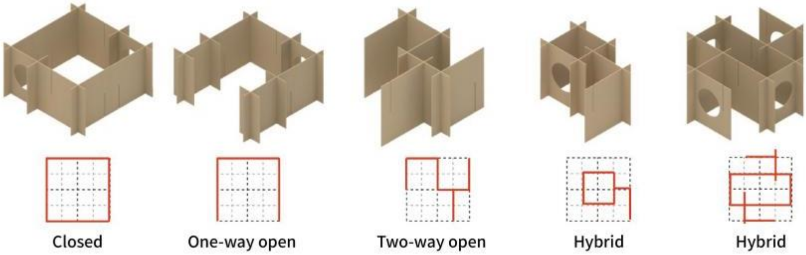

Fig. 6. Main building combinations of the Embodiment Blocks

Figure Source: Drawn by the author

Fig. 7. Example of Space created by the Embodiment Blocks

Figure Source: Drawn by the author

4.3 User Information Records and Results Presentation

Taking one practical class as an example, the children attending the course are primarily under 10 years old, who were considered to be already familiar with school knowledge. As shown in Figure 8, after the first 20 minutes instruction, most of the children used over 90% of their small element blocks for their planning. At the same time, they were able to describe each elements' representing color and deduce specific urban functional scenarios based on combinations of given urban elements. Mean while, there is a reasonable high correction ratio on the corresponding stickers used of the colored blocks. This can from the side, demonstrate the level of acceptance of urban knowledge taught.

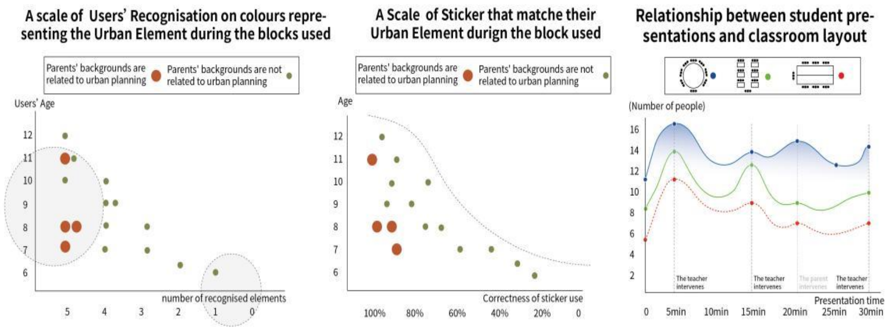

Fig. 8. Series of Accuracy Records on the Urban Blocks

Figure Source: Drawn by the author base on one practice

Based on user's feedback of the embodiment blocks, it can be seen that the majority of students have not got any experience on activities of using large-sized teaching aids, however most students did the blocks building under a high passion.It is worth mentioning that there was a survey handed out before the embodiment blocks were introduced. "How many children (the same size as you) do you think 1 square meter can accommodate comfortably?", the answer to this question shows that students aged 6-12 do not have a clear understanding of 1 square meter, as shown in Figure 9. This lack of spatial sense hint the necessity of embodiment teaching aids and interactive activities in different spatial scales. In the longer term, could help the user to finish their urban block planning under a more objective view.

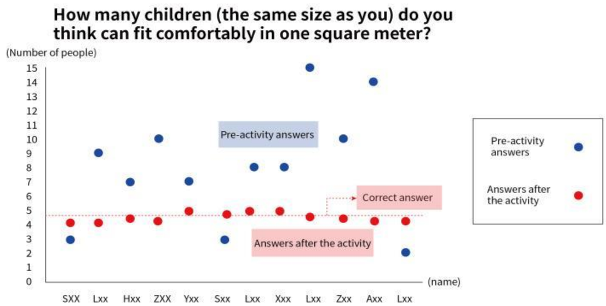

Fig. 9. The result accuracy of the Embodiment Blocks before and after the course

Table Source: Drawn by the author base on one practice

5 Issues Identified

5.1 Poor Communicability

For operative teaching aids such as Urban Programming Blocks, mutual case observation can continuously remind students of the relationship between the colored blocks and the designed urban scenes. Therefore a playable urban teaching tools typically need strong communication capabilities and diverse modes of expression. The previous operational courses have shown that most children aged 6-12 can use urban programming blocks to complete their urban spatial designs and then demonstrate their work for 10 to 15 minutes, including interactions. However, according to Figure 8, the quality of presentation is heavily influenced by the spatial conditions of the teaching venue and the seat arrangement. The procedure of the presentation were also significantly impacted by teacher and parents' interactive guidance. Consequently, even though children users have a strong desire to express their work, a unmovable display from which now used may lead to a bad explaination and less audiences' attention since their couldn't get a better view. This implies a more adaptable and real-time display form for implanting into diverse course spaces. At the same time, a unified presentation context is needed to convey different design concepts to ensure the logical expression of teaching content. These improvements above are yet to present in the current blocks.

5.2 Insufficient Playability

Although various target combinations were anticipated while the blocks were made, the actual choices made by child users during the design process fell short of expectations. In fact, as shown in Figure 10, less than 7% of the users explored beyond the combinations provided in the instruction manual. Without reminders, it is challenging for them to deviate from the expected outcomes. Moreover, they tend to exhibit greater variability in their choices as they grow older. This implies that enhancing the playability in the tool's design depends not only on the possible "answers" but also on the multi-faceted guidance during the teaching process. This enable children to gain a more comprehensive understanding of the tool's logic and possibilities, it is essential to complement it with longer introductory educational sessions or a progressive series of courses.

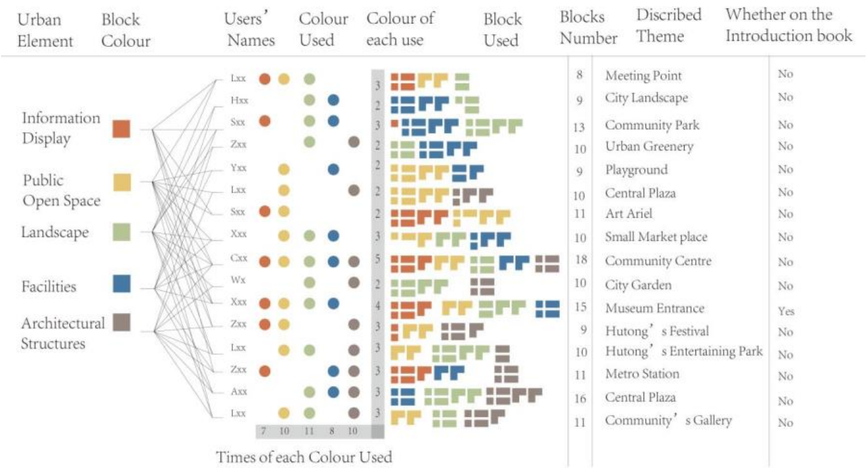

Fig. 10. Users Information on blocks using of the Urban Block

Figure Source: Drawn by the author base on one practice

5.3 Poor Adaptability

Current urban programming blocks are primarily made from wood or recommended PVC materials, with limited variation in material choices. Only colors and shapes are currently employed to distinguish different urban functions. More specific representations rely on stickers with urban details. As shown on Table 1, feedback from users aged 6-12 during experimental courses indicates that wooden blocks surface are challenging to combine with high-tech components or any other attachments. Therefore, during the design process, there are certain limitations imposed on their imagination because of the wooden texture. Additionally, due to the limited amount on blocks and the lack of material used, the means of expressing user's creations tend to be rudimentary. The poor adaptability directly contributes to a reduction in playability.

Table 1. Users Information on sticker using of the Urban Blocks

Users' Name	Age	Stickers Used	Element Mathed	Block Face Sticked	Most Sticked Element	Further Requirement Asked
Lxx	10	15	13	10	Red	None
Hxx	8	8	8	6	Yellow	3D People Figure needed
Sxx	7	6	6	5	Red	None
Zxx	7	5	3	4	Black	None
Yxx	7	10	10	8	Red	3D People Figure needed
Lxx	*8*	8	8	8	Yellow	None
Sxx	*8*	16	13	11	Red	None
Xxx	*7*	10	6	5	Green	None
Cxx	*12*	15	15	13	Red	Light equitment

Wxx	*10*	13	13	10	Red	None
Xxx	*11*	7	7	5	Black	Further attachment possibility
Zxx	*7*	3	2	3	Green	3D People Figure needed
Lxx	*11*	9	9	8	Black	Real Plants pot required
Zxx	*10*	8	4	6	Green	None
Axx	*8*	8	4	8	Red	Screen Needed
Lxx	*6*	12	3	10	Green	None

Table Source: Drawn by the author base on one practice

6 Conclusion

In summary, Urban Programming Blocks, as teaching tools for children aged 6-12, have a great room for improvement in terms of playability. Future development should focus on three key areas. Firstly, as Children aged 6-12 need strong "city image[4]" to built up their design concept and process the storytelling. Therefore, the introduction to each blocks' representative meaning in the early stages appear to be very important. At the same time, as a physical teaching tool, the intuitive characteristics of Urban Programming Blocks greatly assist in teaching content, giving the blocks more vivid connection to the real world. Children's perception of different spatial forms and textures helps them understand various urban forms. Therefore, improving the product's tactile feel and visual design is crucial to enhancing its playability. Secondly, the educational purpose of Urban Planning Blocks is to enable school-age children to master the basic combination patterns of cities and perform them using these blocks. The ability of users to plan an urban scene beyond the provided instructions, demostrating a solid understanding on the taught knowledge and a further exploration. In other words, the diversity of planning results is an essential aspect of the playability of these urban planning-based teaching tools.This hints an increase on the number of basic modules, total blocks and urban attribute variables during the design process. The demonstration or video guidance could be very important for such age users. At the same time, logical expressions such as diagrams expanding the merging principle, as well as a extra physical interaction prompting the right resultant, were considered to be an auxiliary effect on the teaching content of urban knowledge. Nevertheless, what is taught here is an idealized planning principle rather than an absolute law. Lastly, the abstraction and operability of Urban Planning Blocks are the foundation for interfacing with computer processing power and intelligent decision-making. The design of these blocks is a progress that translate the 3D real world into 2D information and make it computable. Providing the blocks this basic characteristics of communication science could facilitating the acquisition of more accurate target users and classifying the tools themselves. For children users, whether it's simulating the spatial placement of smart city or creating digital twins of physical tool, are seems to be an intelligent extensions on the

[4] *The image of the city is* a book written by Kelvin Lynch from 1990. The book is about the looks of cities, and whether this look is of any importance,and where it can be changed.

playability of Urban Planning Blocks. In the future, while the electronic or programming skills are mastered by school-age children, Urban Planning Blocks should develop more interfaces and attachments for sensors to enrich their ultimate application scenarios and presentation methods.

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