Usability Evaluation of Adaptable Urban Park Furniture Product with Cellular Light-weight Concrete as Material

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Usability Evaluation of Adaptable Urban Park Furniture Product with Cellular Light-weight Concrete as Material

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1. Introduction

Urban parks are vital in maintaining the natural environment as an essential part of a sustainable city. However, they also have the potential in improving the social and physical health of a city's inhabitants [1]. Hence, besides preserving green landscape, the design of urban parks should also support the surrounding non-green spaces to become recreational habitual areas that encourage social interactions and healthy motoric activities [2]. Consequently, the design of park facilities such as furniture and other outdoor furnishings should also be a primary concern in the planning of urban parks [3]. In most urban cities there are very few large parks with a preserved natural environment, while many other parks are pocket parks that consist of smaller non-green spaces, located on street edges and road corners, sometimes appearing lifeless and inhabited. Many park furniture are made of conventional materials such as iron or wood that cannot tolerate the intense sunlight radiation, snow and heavy rainfall. Apart from that, the conventional singly-functioned designs of the furniture are insufficient in accommodating the variety of social and motoric activities that can take place in public parks besides sitting. This research develops the idea of using cellular light-weight concrete (CLC) as material for a modular design of park furniture, inspired by Froebel play blocks, in order to provide an

innovative way of accommodating various activities in public parks. CLC is a material made of concrete mortar mixture that has been injected with air bubbles using a foam generator before solidification, resulting in a light-weight concrete block [4] that is resistant to sunlight radiation, rain, rust and termite. The use of CLC compared to conventional concrete enables mobility, supporting changes in park settings from time to time in order to keep the parks attractive enough to draw in visitors. In order to ensure its usability to park users, this research paper focusses on performing usability tests based on Bailey's human performance model in which a design product ought to have equivalent considerations to aspects of human (somebody), activity (something) and context (someplace) [5]. Two types of tests were conducted: formative usability tests during the explorative design process, followed by summative usability test that is conducted post production. Through the usability tests, it is hoped that the modular CLC furniture product yielded can truly accommodate various social and motoric activities in public parks and support the recreational as well as social function of urban parks in contemporary urban cities.

2. Research Method

In a successful human-centered design product, usability tests form a crucial part of the design process. Two methods of usability tests consisting of formative usability test and summative usability test were conducted in this research. Formative usability test is an explorative study conducted early in the design process when a product is still in the preliminary stages of being defined and designed [5]. The main objective of this study is to examine the effectiveness of the design concepts. In this research, formative usability study was conducted based on Bailey's human performance model on performance usability, through conceptual testing of activities that can be conducted with the modular light-weight concrete furniture in variable spaces of public parks by a range of users. This test was done to determine the appropriate final form, dimensions and approximate concrete material mixture of the final product. After production of prototypes with real CLC material, summative usability tests were performed through the lead user method. The purpose of the test is to expand the findings of the exploratory test by direct testing of the product with potential users. In this research, a total of 5 children, 5 teenagers and 5 adults were invited as lead users. The results of the test were then documented and compared with the findings expected from the formative usability tests.

3. Findings and Discussion

From four design alternatives produced prior to this research paper [6], the fourth design, that can accommodate the largest range of activities, has been chosen for development. It also has the smallest size of module that can adapt to variable park spaces and has a massive form that suits light-weight concrete production (figure 1). The form of this module was inspired by Froebel geometric blocks in children toys and modern Froebel architecture. It is a simple cube with cavities to support the interlocking system. The voluminous form is suitable to the CLC concrete material, as the instalment of metal structures as generally found within conventional concrete would be unnecessary.

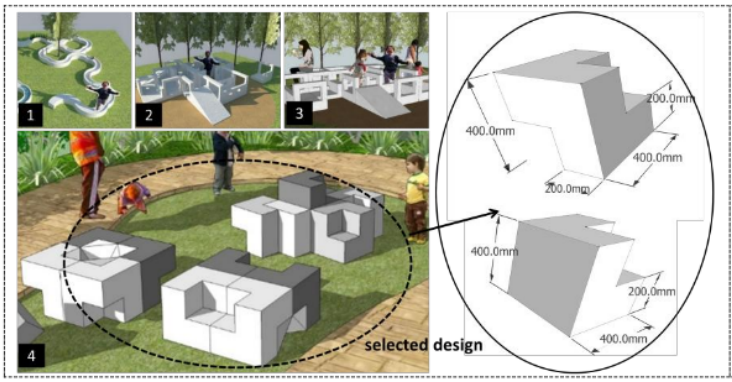


Figure 1. Modular design of cellular lightweight concrete park furniture inspired by Froebel blocks.

The simple geometric block grants opportunities for multiple compositions according to creativity and context, as such is the adaptable purposive function of toy blocks and modern Froebel architecture. The function of Froebel-inspired products would be similar to its pedagogic purposes that garners high considerations on both physical and psychological experiences in a natural environment that facilitates children play [7]. From the selected module, we further explored a range of possible compositions, using three dimensional animation software. Variable compositions could be produced even with a few blocks (less than or equal to 4), medium number of blocks (more than 4 and less than 10) and a large number of module blocks (more than 10) as seen in figure 2.

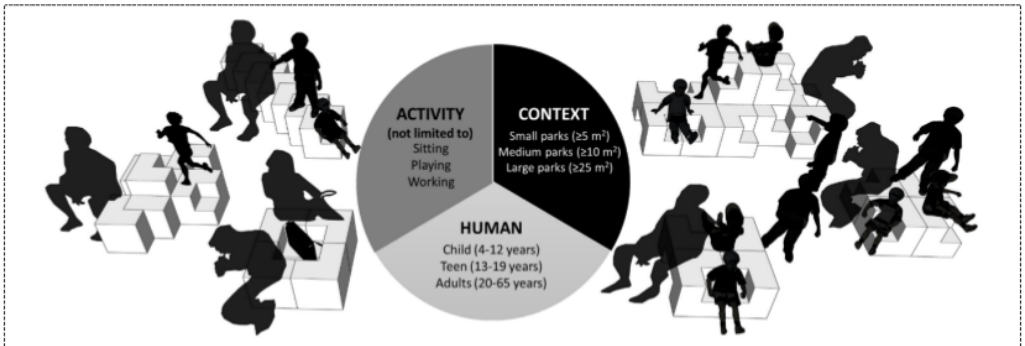


Figure 2. Varying formations of CLC park furniture module accommodating varying activities and spaces based on Bailey's Human Performance Model.

In order to test its usability before further development, the researchers used the triangulation method of considering three aspects in the design based on Bailey's human performance model in testing design products [5]. The three aspects are human, activity and context (place). In regards to the human aspect in this research, the targeted users are children users (4-12 years), teenagers (13-19 years) and adults (20-65 years). The activities targeted for accommodation revolves around sitting, playing and working. Meanwhile the aspect of place considered are parks that has an area of more than or equal to $25m^2$, more than or equal to $10m^2$ but less than $25m^2$, and more than or equal to $5m^2$ but less than 10 m^2, like in the case of pocket parks and street corners. The results of the formative or explorative usability test are articulated and summed up in table 1.

Through the formative usability tests conducted, the authors explored that at least three activities that are not limited to sitting but also climbing and balancing could be conducted with only 2-4 blocks of furniture modules that could be placed on the smallest areas of parks ($5m^2$). The explorative tests, using computer software, showed that they could be used by all target users. Meanwhile, the use of 4-10 module blocks can accommodate more physical or healthy playing activities such as climbing, balancing and jumping. Formations of more than 10 module blocks can combine smaller compositions of 2-4 and 4-10 modules that garner even more variable activities. The explorative possibility of activities that could be accommodated enabled the authors to determine the appropriate dimensions of the blocks. We formulated the dimensions based on standard popliteal and hip-breadth measurements of Indonesian users [8], as majority of the activities would revolve around sitting in the case of both adults and children. This resulted in a 400 x 400 x 400 mm of cubic form with a 200 x 200 200 mm of cavity (figure 2). In terms of module weight, literature studies reveal that the standard maximum load for a single male person is 21.3 kg [9]. With the determined dimensions, the explorative usability test assisted us to adjust the suitable volume of foam in the concrete mixture in order to achieve a weight of about 30-35 kg per module, as it has to be heavy enough to avoid theft, yet light enough to be moved by at least two park workers. The volume of air bubbles should be about 60-70% to achieve targeted density between 750-800 kg/m^3.

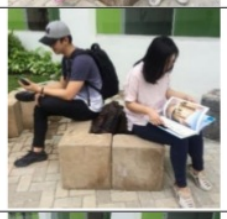
Table 1. Formative (explorative) Usability Test of CLC Adaptable Park Furniture Design

Modules	Possible Modular Arrangement	Activity	Human			Context (Park Space)		
			Child	Teen	Adult	≥5 m² ≤ 10 m²	≥10 m² ≤25 m²	≥25 m²
≥2 ≤4		• Casual Sitting • Chatting • Drinking	√	√	√	√	√	√
≥2 ≤4		• Casual Sitting • Chatting • Drinking • Storing bags		√	√	√	√	√
≥2 ≤4		• Casual Sitting • Chatting • Drinking • Climbing • Balancing	√	√	√	√	√	√
≥4 ≤10		• Casual Sitting • Chatting • Operating mobile devices • Climbing • Balancing	√	√	√	√	√	√
≥4 ≤10		• Casual Sitting • Chatting • Operating mobile devices • Climbing • Balancing • Jumping	√	√	√	-	√	√
≥ 10		• Casual Sitting • Chatting • Operating mobile devices • Climbing • Balancing • Jumping	√	√	√	-	√	√
Conclusion		Variable activities not that are not limited to just sitting and playing could be accommodated even in the smallest area of parks (10 m²) by all target users.						

Figure 3. Summative usability study of the load weight of CLC module

To validate and expand the results of the explorative usability test above, we performed a summative usability test after the production of the experimental CLC module blocks, using the lead user method of evaluation. We invited 5 teenagers, 5 adults and 5 children as lead users in the usability test. The first summative test was performed on behalf of park workers as users and managers of the furniture. With the calculated concrete-air bubble composition as a result of the explorative study, each module block produced weighed between 35-42 kg. Each concrete block could be lifted by two workers but difficult to be moved by one user, as expected in the research (figure 3). In terms of park visitors as users, we compared the results of the formative usability test with the summative usability. The summative test validated and expanded some of our findings in the formative tests as summed up in table 2.

Table 2. Summative usability test of CLC Adaptable Park Furniture Design

Modules	Explorative Usability	Summative Usability	Conclusion
≥2 ≤4			This module formation took up only 0.8 m^2 of space + 30% for circulation and hence can be used in the smallest area of parks. The formation was able to be used as a sitting facility for adults, teenagers and children. The sequential leveling between children and adult seats also benefits social interactions between parents and children.
≥2 ≤4			The module formation took up only 0.8 m^2 of space + 30% for circulation and hence can be used in the smallest area of parks. The formation was able to be used as a sitting facility for adults. Storage areas in the middle proved to be quite functional for college and high school students.
≥2 ≤4			The module formation took up only 0.8 m^2 of space + 30% for circulation and can be used in the smallest area of parks. The formation was able to be used for sitting and climbing for adults, teenagers and children. The sequential leveling between children and adult seats also benefits social interactions between parents and children.

≥4 ≤10			The module formation took up only 1.5 m^2 of space + 30% for circulation and hence can be used in the smallest area of parks. The formation was able to be used as a bench for adults/teenagers, sitting, balancing and climbing facilities for children.
≥4 ≤10			The module formation took up only 2.1 m^2 of space + 30% for circulation and hence would be more suitable for medium to large parks The formation was able to be used for sitting, balancing, jumping and climbing facilities for children, and a sitting facility for teenagers and adults. The varying seat heights also benefit social interactions among parents and children.
≥ 10			The module formation took up 3 m^2 of space + 30% for circulation and hence would be more suitable for medium to large parks. The formation was able to be used for sitting, balancing, jumping and climbing facilities for children, and a sitting facility for teenagers and adults. The varying seat heights also benefit social interactions among parents and children. It is also found that when not used for playing, the adult seat could be used as a table for children to read and write. A large park space can also be used for multiple formations at one spot that can be changed from time to time. This multiple formation can accommodate different activities in different ways, creating multi-function spaces in parks.

Through the summative usability test conducted in the case of visitors as users, it was found that multiple activities could be generated through the Froebel concept of furniture design, even in the smallest areas of parks, just as what has been expected in the explorative usability test. This makes limited park spaces on street edges and pocket parks usable and multifunctional. Expanding results reveal that the varying heights of seats and multi-function nature of the furniture encourages social interaction between adults and children that are not generally accommodated in conventional park furniture. Hence, the design may provide opportunities for parents to play together with their children rather than sit and watch them play in conventional singly-functioned parks. This supports the role of urban parks in enhancing social cohesion between different people of different ages and hobbies, contributing to social equality and social awareness in neighbourhood communities [10].

Other findings from the summative usability test also include limitations in the design product that could be addressed in future design development. First, on a few occasions, the light-weight concrete surfaces were chipped off during the lifting process. This could be countered by re-adjusting the concrete mortar mixture, for instance, by adding fibre or resin to increase the cohesive characteristic of the material. Other limitations include the existence of gaps between the modules when stacked or placed together. This problem could also be addressed in future design development by using thicker steel casts for the moulding process in order to increase their precision when joined perpendicularly. The weight of the material could also be re-adjusted to become lighter than the blocks that have been produced in this research, as some modules weighed as heavy as 40 kg, which was deemed too heavy for some park workers. Nevertheless, the concept of a modular park furniture with a material that is resistant to extreme weather, theft and vandalism that is usable even in limited park spaces, can serve

as an initial idea for future developments of urban parks that should encourage outdoor activities in the indoor-attached and gadget-engrossed society.

4. Conclusion and recommendations

From the usability tests conducted, it can be concluded that modular designs of park furniture using materials that suit outdoor exposure such as CLC have the potential in making parks fulfil their primary purpose of supporting social interactions and physical health in urban cities. It grants opportunities for users of different age groups to perform multiple activities together rather than individually, hence, encouraging family and community bonds within neighbourhoods. Park managers can also play a certain role in creative settings of urban parks. Despite a few limitations found in this research, it can serve as an initial concept of developing future urban parks into novel spaces. Future urban planners and product designers can develop the concept of multifunction products or spaces for urban parks with other modular forms and newly developed materials that can counter typical problematic issues in public facilities such as exposure to extreme weather conditions, lack of space, theft or vandalism. Through this research-design project, the authors hope that urban parks may evolve to become habitual multifunctional spaces for social engagements and healthy recreation that can compete against people's attachment to indoor spaces and gadget devices in the contemporary society.

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