Conceptual design of children’s portable bicycle frame and handlebar

Gabriel Sianturi¹, Lutfi Awil Fuad²
Industrial Engineering Department, Universitas Komputer Indonesia
Jalan Dipatiukur 112-116 Bandung, Indonesia

gabriel.sianturi@email.unikom.ac.id, luthfi17fuad@gmail.com

Abstract. Bicycles for children are widely available on the market in various shapes, sizes and types. The currently available bicycles types in the market are the regular bike that cannot be folded and the folding bike. Although the folding bikes can be folded into smaller sizes but the bike still take much space when it stored, especially if desired to stored the bike in a storage or a case and the bike will be stored for a long time. This paper aims at generating concept design of frame and handlebar of children's portable bicycle that does not take much space when storage and can be carried easily, using conceptual design method. Six concept variants have been generated from a range of possible concepts by combination of solutions in the morphological chart and the best concept variant has been evaluated and selected based on a set of criteria using Pugh concept selection method.

1. Introduction

Bicycles for children are widely available on the market in various shapes, sizes and types. Bicycles Manufacturers made bicycles that are suited to the age of the children. The tricycle is suitable for children aged 1-3 years, while children aged 4-7 years can already use bicycles of two-wheeled children. For two-wheeled bicycles, on the market are available types of regular bikes that can not be folded and the type of bike that can be folded.

A folding bicycle is a bicycle designed to fold into compact form [1]. The folding mechanism on the bike makes the bike easier to carry and does not require large space when the bike is stored. Folding mechanism vary with each offering distinct combination of folding speed, folding ease, compactness, ride, weight, durability and price [1]. Folding bikes for children have a folding mechanism that is not much different from the folding mechanism of adult bikes.

References that focus on research on children's bicycle design are rare. A study of children's bicycle design is done by Xu et al who conducted a study on children's bicycle design using multi-function method. Applicating the method Xu proposed a children bicycle design that has two functions i.e. gliding and riding [2]. Various innovations related to the design of folding bikes or portable bikes have been widely studied. A.K Singh et al and Arunachalam M et al has modified the folding bike into a user-friendly folding bike [1] [3]. Arunachalam et al conducted research on concept design and the embodiment of folding bikes [4]. Ankush Anwar et al.,designed a single fork folding bicycle which is fold in compact form which facilitates easy and easy parking transport [5]. A.K. Jouhri et al invented 4-fold foldable bikes, the bicycle which consist of the four folds [6], while Maleque et al studied the relationship between material properties and designs for folding bikes components and
found that the properties of frame materials such as fatigue and tensile strength is an important property for better frame performance [7].

Observations on the market, the folding bike for children still take much of space when stored especially if the bike is stored in a storage or case and will be stored for a long time. Therefore this paper aims at generating concept design of frame and handlebar of children's portable bicycle that does not take much space when storage and can be carried easily, using conceptual design method, and it takes an innovation design a children's bicycle that can be stored in a small storage container so that the bike is easy to carry from one place to another.

This paper focuses on the design of the children's bike frame and handlebar. In this study, the design is only focused on the concept design of frame and handlebar components. Frame is a main supporting part of the bicycle, while handlebar is the part which use to control the direction of bicycle. Other bicycle components, such as chains, tires, pedals, etc. are not discussed in this study, with consideration of the design of the bicycle components other than frames and handlebar will use standard components in general.

2. Methodology
The design method that will be used in this study is conceptual design method. Conceptual design is one of the phases in the design process using a systematic design approach originally developed by Pahl and Beitz. The systematic design approach consists of four phases, namely task clarification, conceptual design, embodiment design and detail design [8]. The concept design stage aims to develop the concept of variant and then choose the best concept among the concept variants that will be developed further. The conceptual design stage begins by defining problem formulas, establishing overall functions and subfunctions, searching solutions to fulfill the overall function, combining solutions and selecting suitable combinations to generate variance concepts and finally evaluating concept variants. Steps of the conceptual design process undertaken in this study are as shown in Figure 1.

![Figure 1. Conceptual design phase.](image)

3. Result and discussion
In order to provide clear guidance during design activities, design problem is formulated in the early phase of design process. Design problem or task can be formulated as follows: develop concept of frame and handlebar of a children’s portable bicycle so that the bicycle occupy less space when it is stored.
Overall problem can be decomposed into sub-problems and function structures established. The following sub functions are identified based on function structures, they are frame, joint and handlebar. The next step in the design process is to search solutions to fulfill the sub-functions. After solutions has developed, a morphological charts are used to combine solutions from sub-functions that will produce concept variants. A morphological chart is a table of functions and solution means for each function. Normal convention is to list the functions in a column in the left hand side of the table and list possible solution means to the right of each function [9]. Table 1 shows morphological chart consist of sub function and solutions

| Sub Function | Solution |
|--------------|----------|
| A frame      | standard | detachable | fold |
| B joint      | fastener | rivet | weld | magnetic |
| C handlebar | Flat bar | detachable | fold |

Combination of solutions on the Morphological Chart produce many variant concepts, therefore in the process of combining solutions, it is necessary to identify the concept variants of combining so that only potential concept variants will be developed further. The combinations of solutions shown in Table 1 lead to 6 different concept variants as shown in Table 2.

Table 2 shows combination of solutions on the morphological chart and concept variants. In Table 2, the first letter represents the sub-function number and the number represent the number of solutions on the morphology chart. As an example, A1 represents that for sub-function A the solution 1 on the chart is used. In Table 1, subfunctions A represents the frame and the solution 1 represents the standard type, hence A1 states that the frame used on the bike is a standard type.

| Concept Variant | Combination of solution |
|-----------------|-------------------------|
| Concept Variant 1 | A1+B3+C3                |
| Concept Variant 2 | A2+B1+C3                |
| Concept Variant 3 | A2+B1+C2                |
| Concept Variant 4 | A2+B2+C3                |
| Concept Variant 5 | A3+B2+C1                |
| Concept Variant 6 | A3+B4+C2                |

In the evaluation concepts stage, Pugh’s concept selection matrix is developed to evaluate concepts and to select the best concept based on a set of selection criteria [10]. The commercial children folding bicycle that already exist in the market is taken as concept reference, hence each of concepts is evaluated to the reference. The ranking of the concept variants is based on the scale such as (-, 0, +) where a (-) is worse than a (0), which is worse than a (+). If a concept variant is offering a better performance than the reference for a specific criteria then the particular design variant is assigned a (+) rank. If it is offering a worse performance than the reference, a (-) rank is assigned. If the performance of the reference and a concept variant is same for a specific criteria, a (0) rank is assigned. Calculation for each concepts shows that concept 3 has a highest final score of 2, hence concept 3 will continue to be developed in the next design phase.
Table 3. Pugh’s concept selection.

| Selection criteria | Concept 1 | Concept 2 | Concept 3 | Concept 4 | Concept 5 | Concept 6 |
|--------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Storage space      | -         | +         | +         | +         | -         | +         |
| Dimension Frame at Saved | 0  | +        | +        | +         | 0         | 0         |
| Dimension Handlebar at Saved | 0 | 0 | + | 0 | - | + |
| Portability        | 0         | 0         | +         | +         | 0         | +         |
| Ease of Assembly and Disassembly | + | - | - | - | - | - |
| Maintainability    | 0         | 0         | 0         | 0         | 0         | -         |
| Ease of manufacture | 0         | -         | -         | -         | +         | -         |
| Quantity +         | 1         | 2         | 4         | 3         | 1         | 3         |
| Quantity 0         | 4         | 3         | 1         | 2         | 3         | 1         |
| Quantity -         | 1         | 1         | 2         | 2         | 4         | 3         |
| Final Score        | 0         | 1         | 2         | 1         | -3        | 0         |
| Develop?           | No        | No        | Yes       | No        | No        | No        |

The selected concept 3 shown in Figure 2 proposes design which has easy detachable frame and detachable handlebar. The frame are divided into two parts, front frame and back frame. Front frame can be folded and can be connected to back frame by fasteners. Handlebar also can be disassemble into 3 parts. The proposed design in concept 3 offer a concept that it take much less space when storage, easy to assemble and disassemble and easy to carry.

Figure 2. Selected concept of frame and handlebar.

4. Conclusion

In this study concept design of children portable bicycle frame and handlebar has been proposed. Conceptual design method has been performed to generate concept variants. Combination of solution that fulfill sub function has generated six concept variants. Selection concept variant has led to the best concept of bicycle frame and handlebar that will be develop in the embodiment design phase.

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