Book trolley design for Telkom University Library using User Centred Design (UCD) method

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Abstract. Telkom's library book trolley is a tool to help visitors and librarians returning and shelving books. There are still many complaints from the visitors about the library environment which is untidy and some discrepancies between the information about book's availability on the website and on the bookshelf. In addition, there are complaints from librarians about the visitor's habit which is not follow the guidance in the process of returning books and existing trolley books are small and difficult to control. The purpose of this study is to develop the design of Telkom library book trolley in accordance with the wishes of users using User Centred Design method as a concept to determine the design of Telkom's library book trolley parameters. Survey was conducted to identify user criteria and statistical analysis was used to test the developed hypotheses. The results of this study are the design of Telkom library book trolley parameters that can represent the wishes of users and present Effective, Safe, Healthy, Comfortable, and Efficient designs. Based on the validation test using marginal homogeneity test, the design is valid in fulfilling the design criteria that the user want with the significance of 5%

Keywords: User Centred Design, Effective, Safe, Healthy, Comfortable, Efficient

1. Introduction
Telkom University has a library called Open Library. Located in Manterawu Building on the 5th floor has more than 80,500 collection titles with a number of copies of more than 123,937 and has been accredited "A" from the National Library of Indonesia in 2015 (Library, 2011). Telkom University Library has an area of 3200 m² and students and outside parties can take advantage of several services provided including book return areas, luggage storage lockers, discussion rooms, mini theatre areas, café areas, multimedia areas, and free areas. Telkom Open Library provides rules that visitors who do reading activities are not permitted to return the book to the shelf but to the place provided (Library, 2018). This was done to maintain the orderliness of the location of the book. But in practice the book return activity still has several obstacles, many visitors do not know the position of returning the book provided so that visitors simply put the reading book on the table or elsewhere, visitors who do not know the rules will likely return the book to an inappropriate rack location, visitors who know the location of the book return feel lazy to go to the location because of the long distance of return, and lack of socialization to return the reading book to the place provided and the regulations in the Telkom Open Library. The Librarian’s problem is that librarians are less efficient in the process of returning books because librarians need additional time to stack books that are scattered and bring them to where the time needed for the process requires more time and effort and can occur. Musculoskeletal disorders
(MSDs). Librarians put all the books they want to return at an open table so that visitors take back the tidied book even though there is an appeal not to be taken back during the return process. Librarians use ordinary book trolleys that can only accommodate books relatively little in a matter of amount, so they require a long operating time to return, and librarians will be troubled to rearrange books that are not in accordance with their location because visitors put back the books that are read into the shelves that do not match the location.

Referring to the background of the existing problems, this study focuses on the study of the design of book search tools that are in accordance with user requests to provide comfort and convenience in the process of returning books. Therefore, the method used to obtain information and analyse all user needs is considered better using a multidisciplinary approach in which engineering competition is combined with quality tools that are centred on the desires of users or specifically for librarians and visitors of the Open Library.

2. Methods

2.1. User Centred Design Definition
User Centred Design (UCD) is an approach in designing that places the user as the centre in the design process (Vredenburg, 2002). UCD as one of the design methods is a philosophy based on the needs and interests of users, there is a large influence by users who actively determine the desired design and process that is done repeatedly so that the product desired by users can be fulfilled and understood by all users (Norman, 2013). UCD is a subset or part of Human centred Design (HCD), but it leads to interactions that will occur to users when using products or services that have been designed. UCD and HCD use the same methods and stages but are slightly different in the final concept. If UCD focuses on reciprocal users of a product, HCD focuses on how the product interacts with the overall senses of the user starting from the impact on psychology and other things. The most important part of the UCD method is divided into two. UCD always involves users directly during the design development process and the process is carried out in a repetitive manner in the hope that the products needed by the user can be fulfilled.

2.2. Stage in User Centred Design
a) Understand and specify the context of use at this stage, the process of identifying subjects will use the system or product. This will explain the purpose in certain environmental conditions when consumers will use the system or product. Analysis of existing systems or products such as providing information about problems, including deficiencies and levels of performance and basic satisfaction even though obstacles may be ignored but must be met by the system or product in the future. In this study data collection will be carried out by interviews, observations as well as questionnaires
on consumer needs to librarians and visitors to find out the constraints, inputs, and additional information to improve the quality of products to be made.

b) Specify the user requirements, this stage is the process of identifying user needs and establishing functional and other requirements for product or system design. These requirements are intended to be in the context of use for changing new work styles or opportunities to combine products with existing services. In this study data collection will be carried out in the form of attribute validation to be given to respondents.

c) Produce design solutions, this stage is done to bring together the needs of users with design designs that have been developed. In this study, the Axiomatic Design approach is used which starts with mapping of customer attributes to design parameters. This stage aims to validate a design according to the needs and desires of the user. Users will be involved in assessing the design of the design that has been made so that the needs and desires of the user can be clearly described.

d) Evaluate the design, in this stage, the design that has been shown to the user for the next assessment process will be evaluated. Evaluation has the purpose of looking for deficiencies of designs that have been made to suit the needs of users.

![Figure 2. Designing stages of User Centred Design based on ISO 9241-210: 2010 (Standardization, 2010)](image)

The advantage of using the User Centred Design method is it lies in full user involvement starting from the design process to the development process. The general product design focuses on the system level design to complete alternative designs, while using the User Centred Design method will continue to implement a simultaneous system between user feedback and alternative concept design processes.

3. Result & Discussion

3.1 Shelving Process
The shelving process in the Telkom Open Library is done twice / day at 8:00 and 15:30. The shelving process is carried out by librarians and other staff and lasts 45 minutes or 1 hour 30 minutes. The shelving process starts collecting all the books in the administrative services and reading books used in the library to the shelving table, then the librarians and staff do book solving according to the book classification, then return the book to the shelf according to the classification, and finally check the books which is on the shelf according to the classification or not. If it turns out that there is a book that is not in place according to its classification, the Librarian and staff will return the book to its proper place.

3.2 Recapitulation of Number of Books Returned
The number of books returned to the shelves is 6 days every hour the shelving activities are carried out. This is done to get the average number of books returned to determine the capacity of products that can
be accommodated.

Table 1 Recapitulation of Number of Books Returned

| Day/Date  | Time  | Total |
|-----------|-------|-------|
|           | 08.00 | 15.30 |
| Monday    | 476   | 266   | 742   |
| Tuesday   | 396   | 306   | 702   |
| Wednesday | 385   | 288   | 673   |
| Thursday  | 462   | 372   | 834   |
| Friday    | 322   | 286   | 608   |
| Saturday  | 258   | -     | 258   |
| Total     | 2299  | 1518  | 3817  |
| Average   | 383,16| 253   | 636,16|

3.3 Respondent Profile
Based on the proportion, the number of samples in this study is unknown, then testing the sample in this study has a minimum limit of 68 respondents. But in this study we used 120 respondents to represent the population of users of the means to return books in the Telkom Open Library and 5 Librarians.

3.4 Needs Statement Identification
Ergonomics requirements can be reduced according to ergonomic aspects, namely EASNE (Effective, Safe, Healthy, Comfortable and Efficient). The collection of data regarding the identification of user needs is done using an open questionnaire and attributes derived from the representation of consumer statements.

Table 2 Needs Statement List

| Requirements | Ergonomics | Description of Needs Statement |
|--------------|------------|--------------------------------|
| Effective    |            | The shelving process time will be shorter |
| Safe         |            | Strong product construction |
| Healthy      |            | Made of strong material |
| Comfortable  |            | Minimize the energy released by the user when using the product |
|              |            | Product design that seems neat |
| Efficient    |            | There is a sign to inform the procedure and rules for returning the book |
|              |            | Number of interactions with the product |
|              |            | Book return mileage |
|              |            | Number of products for reading location |
|              |            | Travel time needed for product transfer |
|              |            | The quantity of books that can be accommodated |

3.5 Customer Attribute (CA)

Table 3 Translation of Customer Attribute

| No | Customer Attribute | Code |
|----|---------------------|------|
| 1  | Effective           | CA1  |
| 2  | Safe                | CA2  |
| 3  | Healthy             | CA3  |
| 4  | Comfortable         | CA4  |
| 5  | Efficient           | CA5  |

3.6 Mapping Functional Requirement (FR) to Design Parameter (DP)
The produce design solutions process in the stages of the User centred Design method is to obtain attributes from the book trolley design and shelving activities by librarians and staff and the visitor's needs can represent the user's overall needs, then the mapping process is carried out using the Axiomatic
Design approach. This stage is carried out to provide a deeper explanation of the mapping process. When the Customer Attribute (CA) has been identified, the next step is mapping the CA into a function (FR) which will then be answered by the Parameter Design (DP) as a solution.

**Table 4 Customer Attributes “Effective”**

| Code (FR) | Functional Requirement | Code (DP) | Design Parameter |
|-----------|------------------------|-----------|------------------|
| 1         | Able to achieve predetermined goals | 1         | Effective design |
| 1.1       | Can be used optimally | 1.1       | Reduced time shelving process |
| 1.1.1     | Can accommodate extreme size books | 1.1.1 | The dimensions between book slots are adjusted |
| CA1       | The biggest book specifications | 1.1.1.1 | Book height > 32 cm |
| 1.1.1.2   | Rack numbers that have extreme size books | 1.1.1.2 | Bookshelf number 01,02,13,23,24 |
| 1.1.1.3   | Distance between book slots | 1.1.1.3 | 35 cm |
| 1.1.2     | Can divide books by book category | 1.1.2 | It has the coloring of each book category |
| 1.1.2.1   | Number of colors in the product category | 1.1.2.1 | 24 colours |
| 1.2       | User interaction with the product | 1.2 | Number of user interactions with the product |
| 1.2.1     | Number of selected concept interactions | 1.2.1 | 3-5 times |

**Table 5 Customer Attributes “Safe”**

| Code (FR) | Functional Requirement | Code (DP) | Design Parameter |
|-----------|------------------------|-----------|------------------|
| 2         | Design that does not endanger the user | 2         | Strong design |
| 2.1       | Safe construction | 2.1       | Strong construction |
| 2.1.1     | Provides a strong connection | 2.1.1 | The connection adjusts the diameter of the construction |
| 2.1.1.1   | Connection in book slot and buffer | 2.1.1.1 | Slot connection |
| 2.1.1.2   | Pedestal connection with wheels | 2.1.1.2 | Bolt connection |
| 2.1.1.3   | Base connection with frame | 2.1.1.3 | Weld connection |
| 2.1.1.4   | Skeleton connection with support | 2.1.1.4 | Bolt connection |
| CA2       | Provide safe material | 2.2 | Has material that is not harmful to the body |
| 2.2.1     | Strong component material | 2.2.1 | Type of component material |
| 2.2.1.1   | Material type skeleton | 2.2.1.1 | Stainless Steel |
| 2.2.1.2   | Type of book slot frame material | 2.2.1.2 | Stainless Steel |
| 2.2.1.3   | The type of tool material is neat | 2.2.1.3 | Stainless Steel |
| 2.2.1.4   | Type of buffer material | 2.2.1.4 | Stainless Steel |
| 2.2.1.5   | Material type of book holding aid | 2.2.1.5 | Canvas |
| 2.3       | Expenses that can be borne | 2.3 | Product strength |
| 2.3.1     | Material strength in holding heavy | 2.3.1 | 200 kg |

**Table 6 Customer Attributes “Healthy”**

| Code (FR) | Functional Requirement | Code (DP) | Design Parameter |
|-----------|------------------------|-----------|------------------|
| 3         | Provides minimum workload for users | 3         | Workload and body position |
| 3.1       | Frequency of transfer of work location | 3.1 | The number of frequencies the operator makes a move |
| 3.1.1     | Amount of displacement frequency | 3.1.1 | 1x transfer / schedule |
| 3.2       | Dimensions in accordance with Indonesian anthropometry | 3.2 | Dimensions according to percentiles |
| CA3       | Height dimension | 3.2.1 | Percentile height |
| 3.2.1.1   | P50 | 3.2.1.1 | 172 cm |
| 3.2.2     | The dimensions of the length of the palm | 3.2.2 | Percentile length of palm |
| 3.2.2.1   | P50 | 3.2.2.1 | 19 cm |
| 3.2.3     | Elbow height dimensions when standing | 3.2.3 | Percentile elbow height when standing |
| 3.2.3.1   | P50 | 3.2.3.1 | 107 cm |
Table 7 Customer Attributes “Efficient”

| Code (FR) | Functional Requirement | Code (DP) | Design Parameter |
|-----------|-------------------------|-----------|------------------|
| 5         | Able to reach goals with little effort | 5         | Easy and fast process |
| 5.1       | Provide information as visible instructions | 5.1       | Information that can be read clearly |
| 5.1.1     | Instructions for returning reading books | 5.1.1     | Directions that will be placed on each trolley |
| CA5       |                        |           |                  |
| 5.1.1.1   | Type of instructions   | 5.1.1.1   | Banner           |
| 5.1.1.2   | Banner size            | 5.1.1.2   | 85x200 cm        |
| 5.2       | Provides ease of operation | 5.2       | Quantity and capacity |
| 5.2.1     | The number of trolleys needed | 5.2.1     | 4 pieces         |
| 5.2.2     | Product distance to reading location | 5.2.2     | 3-5 meter        |

Table 8 Customer Attributes “Comfortable”

| Code (FR) | Functional Requirement | Code (DP) | Design Parameter |
|-----------|-------------------------|-----------|------------------|
| 4         | Provides a comfortable impression | 4         | Comfort of use   |
| 4.1       | Coloration in product components | 4.1       | Type of component color |
| 4.1.1     | Color frame type         | 4.1.1     | Silver           |
|           |                         |           | Red, dark red, blue, dark blue, light blue, yellow, orange, green, dark green, light green, white, black, brown, pink, gray, cream, purple, orange red, yellow orange, greenish yellow, turquoise, kevioletic blue, red-black, bluish brown |
| 4.1.2     | The color frame of the book slot frame | 4.1.2     |                  |
| 4.1.3     | The type of color of the tool is neat | 4.1.3     | Adjusted to the color side of the categorization |
| 4.2       | Has a tool to tidy up books on a shelf | 4.2       | The tool specifications are neat books |
| 4.2.1     | The dimensions of the tool tidy up the book on the shelf | 4.2.1     | 27x1x21 cm |
| 4.3       | Able to provide good control | 4.3       | Wheel and handle design |
| 4.3.1     | Comfortable wheel design | 4.3.1     | Wheel specifications |
| 4.3.1.1   | Wheel type              | 4.3.1.1   | Caster wheel 80  |
| 4.3.1.2   | Wheel size              | 4.3.1.2   | 4 inch           |
| 4.3.2     | Comfortable handle design | 4.3.2     | Handle shape and specifications |
| 4.3.2.1   | Shape handle            | 4.3.2.1   | Overall connected handle |
| 4.3.2.2   | Handle size             | 4.3.2.2   | Diameter 3 cm    |
| 4.4       | Has a book holding aid  | 4.4       | Book anchoring tool specifications |
| 4.4.1     | Dimensions of book holding aids | 4.4.1     | 150x1x3 cm |

3.7 Virtual Design and Alternative choice
To get a library book trolley that suitable with the wishes of the user, an alternative choice is given to the library book trolley user. In this study 2 alternative choices of virtual design were given to respondents. After selecting from the two alternatives given to users of library book trolleys, the results obtained and selected were designs that truly desired the users and the chosen designs correctly represented the desires of users. In this study the design chosen was design 1 with a very agreeable level of 58% greater with design 2 which was only 34%. Figure 3 is the design of the selected proposal.

3.8 Proposed Design Validation
Design validation is done by comparing the design that the user wants in this case is Effective, Safe, Healthy, Comfortable, and efficient with the chosen design measured at a significance level of 5% (0.05). The effective attribute with product description can be used optimally z values of 0.66, on safe attributes with safe product description when using z values of 0.112, on healthy attributes with product description can reduce workload of workers and reduce the risk of accidental z values of work 0.159, the convenient attribute with product description can provide a comfortable reading location environment of z values of 0.561 and z values of interesting product information of 0.655, in the efficient attribute the product description can inform the return location of the z values reading 0.482, the product information can
inform book placement in accordance with book z values classification of 0.261, in the product description can inform the details of the process of returning the reading book z values of 0.506, in the product description it is easy to reach z values of 0.453, on product description easy to use z values of 0.383, on product description has a large amount of z values of 0.452, in the product mobility statement high z values are 0.141, and in the product description it can contain many books having z values of 0.401. Based on the overall z values that have been obtained from each attribute, it shows that the value of Z> 0.05 means that there has been a match between the designs made with the design desired by users of the Telkom University library book trolley.

3.9 Evaluation
The evaluation in this study is the final process of the design that has been chosen. Selected designs are evaluated to get improvements in selected designs so that selected designs are expected to be better. There are several evaluations obtained from librarians and respondents, among others, giving evaluations of product construction, color adjustments to products, giving numerical information for categorization in addition to coloring, product placement in strategic areas, material evaluation, and evaluation of RULA & OWAS. Figure 4 are the results of the proposed design evaluation

![Figure 3. Design proposal for Telkom University library book trolley](image1)

![Figure 4. Result in Selected Design](image2)

4. Conclusion
The use of sections to divide the text of the paper is optional and left as a decision for the author. Where the author wishes to divide the paper into sections the formatting shown in table 2 should be used. The results of the identification of needs statement has 5 attributes (Effective, Safe, Healthy, Comfortable and Efficient) that needed to be developed towards the design of the Telkom University library book trolley. The design of parameters generated through the mapping process is a trolley design has a size of 35 cm (DP1.1.3) distance between slots because on the bookshelves in the Telkom University library there is a book that has a height that fits 32 cm so that 1 cm is added so that the user will more easily insert the book into the cart. Book trolleys are categorized by color and number of books so that in the trolley design there are 24 colors (DP1.1.2.1) including red, dark red, blue, dark blue, light blue, yellow, orange, green, dark green, light green, white, black, brown, pink, gray, beige, purple, orange red, orange yellow, greenish yellow, greenish blue, blue, red and blue brown (DP4.1.2). In the case of a book trolley construction made by paying attention to the strength of the product with the connection in
the book slot and the support using the slot connection (DP2.1.1.1), on the base connection with the wheel using a bolt connection (DP2.1.1.2), on the base connection with a frame using welded joints (DP2.1.1.3), on skeleton joints with supports using bolt joints (DP2.1.1.4). In addition to the construction of products also made by paying attention to the product material with the selected material on the frame is stainless steel material (DP2.2.1.1), on the frame of the selected material book slot is stainless steel (DP2.2.1.2), in the neat tool selected material is stainless steel (DP2.2.1.3), and the supporting tool for the book material used is canvas (DP2.2.1.4). With the material and construction the book trolley can withstand a load of 200 kg (DP2.3.1). Product size adjustments are used to make products that are convenient to use by operators, products are made based on Indonesian anthropometric references with the reference used is eye height when standing using the P50 percentile with a size limit of 172 cm (DP3.2.1.1) and palm length using percentiles P50 size limit of 19 cm (DP3.2.2.1). In the product, there are several features including a book cleaning tool with a dimension of 27x1x21 cm (DP4.2.1) and a book holding aid with a size of 150x1x3 cm (DP4.4.1). In addition, the wheel selection is obtained by the wheel type Caster wheel 80 (DP4.3.1.1) with a 4 inch wheel size (DP4.3.1.2), an overall handle design (DP4.3.2.1) with a diameter of 3 cm (DP4.3.2.2). Coloration in addition to the book slot frame but also on a colored or fixed frame (DP4.1.1) and it is expected that the book trolley design can reduce the number of operator transfers to only 1x displacement / schedule (DP3.1.1) and user interaction is only 3x-5x interaction (DP1.2.1). The selected trolley book will be placed at several strategic points with a number of trolleys of 4 (DP5.2.1). To provide information about the procedure for returning books, the location of returning books, etc. regarding the return of books, information media in the form of banners will be placed next to each product (DP5.1.1.1) with a banner size of 85x200 cm (DP5.1.1.2) and the distance of the trolley and tire to the reading location only ranges from 3-5 meters (DP5.2.2).

Based on the validation test using the Marginal Homogeneity Test, the design is valid in fulfilling the design criteria that the user want with the significance of 5%.

5. Reference

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