Characteristics Identification and Redesign of Consumer Product Based on Universal Design Principles

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ABSTRACT: The aim of this research was to identify characteristics of each group of users. Groups of users that were involved were deaf people, handicapped people, children, aging people, normally adult people in productive age’s range, and blind people. By understanding each group of users’ characteristic, some obstacles could be indentified. Based on universal design principle, some obstacles and discrepancies in using product will be minimized. Products that were used in this research, were pliers, scientific calculators, and plastics bottles. It was because those product represent human’s sense of touch, human’s eyesight, and human’s energy expenditure. In spite of it, some aspect of human capabilities such as psychomotoric variable, sensory variable, cognitive variable, were considered to be tested by using some instruments. Based on those testing, characteristic of each group of users could be well defined. Product which were used in this research, did not fully meet universal design principle. Recommended design of pliers are changing and adding contour and some fatures, visual display, and adjusting dimension of pliers with users’ palm. Recommended design of scientific calculator is eliminating some buttons and size of the letters on the buttons. Recommended design of plastic bottle are design of those products are organized to fulfill the universal design principles and accommodate some obstacles which are experienced by all groups of users.

Keywords: Universal design and consumer product

1. INTRODUCTION

Rapid advancement of technology presents motivation to existing products at present, among others consumer products. In consumer products, interaction between user and product is very high because frequency of using the product is possible to occur frequently. The user of consumer products is very diverse, from the aspect of age, ability and experience. A product could be utilized by the elderly, adults, as well as the children age group where the individual ability and experience are different. There are users which are actually potential however because the product’s design characteristic is not sustainable for the potential user hence mentioned product is not used. The meant potential candidate user is the user having the opportunity and need to utilize the product and mentioned user is indeed judged proper when using mentioned product. Besides that, there are users who have limited physical ability in utilizing the product. The physical limitation undergone by the product user is indeed very diverse, starting from single disability until multiple disabilities.

Generally, existing products are designed for the normal user group so that other user groups would face difficulty in using the product, for example an elderly using a scientific calculator to perform a complicated calculation therefore frequently mentioned elderly undergoes difficulty to identify the number on the buttons as well as on the calculator display screen. Based on above mentioned condition, could be concluded that products circulating in the market are not applied with overall or universal design principles. Universal design principles make it possible for all would be potential users to utilize the product optimally so that the form and feature of the product would present a maximum function. Physical disability and age which might influence the utilization of products could be minimized by the universal design principle. Besides that, design of products by taking into consideration the universal design, present profit to companies or designers. By applying the universal design in designing a product, the company could extend its market target so that obtained profit would increase.

In this research three family products are used, i.e. pliers, plastic bottle, and a scientific calculator. Every product consists of three product types. These three products are used because they are familiar to the user. Besides that, these three products also represent several aspects or human body sensations, i.e. touching aspect, seeing aspect, energy discharging aspect, as well as a certain learning in using the product. In
connection with above explained problem therefore the purpose of this final assignment research could be outlined as follows:

- Analyse design characteristics of consumer products circulating in Indonesia.
- Analyse and identify the limitations undergone by each user group when utilizing products.
- Redesign consumer products based on the universal design principles where mentioned proposal is adjusted to characteristics of the Indonesian citizen until all would be users could obtain maximum benefit of the product.

2. METHOD

To obtain a logical result therefore in performing research systematic steps are needed. The steps taken in this research are commenced by performing a preliminary study, determining the research topic, and further performing a literature study and field study to find the proper solution to the problem. When the problem has been specifically determined then several related problems are formulated by imposing several limitations and assumptions. Furthermore, the purpose and benefit of the research are also determined to respond to above problem formulation. At this initial stage, comprehension of the universal design and its principles should be studied further. The principle of universal design itself consists of [1]:

- Low Physical Effort
- Perceptible Information
- Simple Use
- Safe, Secure, and Private Use
- Adaptability to User Pace
- Tolerance for Error
- Equitable Use
- Intuitive Use
- Flexibility in Use
- Reach and Access for Use
- Size for Use

The performed compiling and processing of data covers the determination of family and product type, i.e. pliers product, scientific calculator, and plastic bottle. Hereunder are the products used in compiling data:

![Figure 1: Pliers (type A, B, and C)](image1)

![Figure 2: Plastic Bottle (type A, B, and C)](image2)

![Figure 3: Scientific Calculator (type A, B, and C)](image3)

After the product is determined, then the user groups which would be researched are determined. Because of universal design, therefore subsequently the researched user groups are very diverse, especially users with certain limitations. The involved user group is the normal productive age group with an age span of 20-30 years. This user group is going to be the comparison reference towards other user groups. The
Children group with an age span of 7-13 years and the elderly group with an age limit of above 65 years. Besides that, also involved are users with physical disability comprising the deaf, the blind, and the disabled with an age span of 20-30 years. The collecting of samples for each user group is carried out by the convenience sampling method and follows the Roscoe rule. Each user group consists of 12 respondents.

The further stage is to determine a number of task lists adjusted to the needs and functions of the products used in this research. Initial interview is performed with 4-5 respondents from each user group. When the task list has been determined at the same time the test types which should be done are determined. The performed test covers the grip strength test using the grip dynamometer with the purpose to find out the grip strength of each user group. The user’s hand palm dimension test is performed using calipers. The eye hand coordination test uses the Lafayette Instrument and disc with the purpose to find out the concentration and coordination level created between hand and eyes in each user group. The tactile discrimination test using the tactile recognition shape with the purpose to find out form and combination whether the equal shape or the different shape is the easier to be identified by each user group. The digit span and implicit recall test with the purpose to find out the memory capacity or the level of remembering power of each user group by using letter cards and numbers. The near reading visual acuity test with the purpose for seeing ability of each user group by using the Landolt C-test. This Landolt C-test uses the letters of Arial and Times New Roman with the letter size of 6 pt-14 pt. The last test performed is preference for color by replacing the interface product the user is expected to choose a color suitable for each product. The tests performed above represent the sensory, psychometric, cognitive, and physical aspects of the user. Besides that, the test is also adjusted to the universal design principle although several universal design principles could not be represented by mentioned experiments.

When all instruments are determined then data compiling is performed which consists of two categories, i.e. data linked to the product and the human body’s ability aspect. Data linked to the product covers working time data, amount of mistakes, and the questionnaire’s value. The questionnaire used is a questionnaire compiled by the North Carolina State University. Data linked to the human body’s ability aspect is obtained by performing above mentioned tests. Mentioned data are further processed by using the normality data test, Pearson correlation test, data variant test, ANOVA RBD test, and Mann-Whitney U significance test.

Based on tests and statistical data processing therefore a characteristic could be obtained from each user group. This characteristic would become one of the references in determining the product design proposal based on the universal design principle. The last stage is performing analysis based on the results obtained from data processing and drawing final conclusion from this research.

3. DATA AND RESULT

Based on above mentioned research methodology, therefore the obtained data are processed using a certain statistical test. The questionnaire data is tested using the data normality test, Pearson correlation test, data variant test, and ANOVA RBD test. Other data are processed using the Mann Whitney U significance test where the normal productive age is made as comparison reference. This matter is caused because this group has the most optimal human body aspect ability among the other user groups.

The data normality test formed a prerequisite for the performing of the Pearson correlation test and the ANOVA RBD test. The Pearson correlation test is aimed to know about the closeness or correlation connection between the questions items in one same universal design principle mentioned in the research questionnaire. The data variant test’s objective is to know about the data spread among the user groups. This test is also a prerequisite for performing the ANOVA RBD test. Whereas the ANOVA RBD test’s objective is to find out the difference in usage among the user groups and the influence on the difference of the product’s type. This test is performed for the eleven universal design principles at each product family. Through this test could also be identified, which universal design principle is fulfilled or not fulfilled by each product design used in this research. The Mann Whitney U significance test is aimed to identify the average difference among each user group, this ANOVA RBD test averagely presents results that the eleven universal design principles are not yet fulfilled by the products used in this research. This is caused by the majority of the users who could not utilize the product properly and does not comprehend the figures on the product. The Mann Whitney U test presents a more variant result for the tested human body ability aspect.

From the research results could be obtained several characteristics of the user group. The deaf group underwent hearing impairments which hampered communication. This caused a low comprehensive capacity and perception of the deaf user. But their nerve and muscle functions are like normal users. The handicapped (disabled) user group has a limitation in releasing energy caused by occurrence of nerve and muscle dysfunction and abnormal structure of the majority of the limbs. Generally, the brain function is also
impaired as a consequence of disability and undergoes mental retardation. This causes decrease in perception and comprehensive capacity.

The blind group undergoes visual impairments however their feeling and hearing senses are very sharp therefore intuitively, this group could comprehend and utilize products. The children group has limitations in releasing energy and experience because they are still in the development stage towards a normal productive age. But in general children have a sharper comprehensive ability and intuition. The elderly undergo decline in all aspects of the body’s ability, in energy release, hearing, feeling, sight, as well as comprehensive ability. Whereas, for the normal productive age all human body abilities aspects function well.

Based on test results, could be obtained that the form which is easier to be identified is the square with an equal shape combination. From the near reading test results is acquired that arial letters are easier to be identified than times new roman letters. Letter size which is generally readable by the six user groups starts from 12 pt. therefore it is suggested that in designing a product, the minimum letter size should be 12 pt. In the grip strength test result obtained is that the minimum grip strength belongs to the handicapped, children, and elderly group. For the palm dimensional test, significant difference is found in the handicapped, children, and elderly group. Whereas in the digit span test and implicit recall tests, the most mistakes are found in the elderly, handicapped, and deaf user groups. The eye hand coordination test proofs that the elderly and the handicapped has the longest working time. The last test i.e. preferences for color, presented the same results for the three products.

By referring to the test results, related references, and comparison with available products, therefore a product design proposal could be presented based on the universal design principle. As follows are presented proposed product designs and further explanations.

Improvement is performed in the product design proposal. Proposed improvements could be simple or complex of nature. The purpose of this improvement is to expand would be potential users and in order that users with certain limitations could use the product like any normal user without being differentiated. The proposed repairs are as follows:

For the pliers:
- Addition of protrusions at the handle’s edge. This addition of protrusions is intended to avoid the user’s hand being clamped when using pliers in a closed position.
- Addition of knurled contour half diamond type with a distance of 0.2 cm. Knurled contour is a contour suitable for the pliers’ handle. Addition of contours is intended to avoid the hand from slipping when using pliers and to minimize the energy needed to hold the pliers. Contours are made denser and smoother in order that the produced rubbing force between handle and palm is not too big and the user stays comfortable when using pliers.
- Adjusting the pliers dimension with the average users’ hand size, i.e. using a percentage of 50 with pliers’ length of 16 cm and a maximum grip span of 9 cm. The grip’s span size is also adjusted to the percentage of 5 from the maximum grip strength which could be produced by women users.
- Addition of the text CUT at the cutting part with a size of 18 pt. This text addition is intended to supply information to the user which is the
- Groove turns fiture and which is the cutting section. The text size is made bigger in order that the user is able to identify mentioned text without difficulty at a certain distance sight.
- The handle’s colour is adjusted to the average users’ colour choice, i.e. blue.
- The pliers’ weight is 1.76 kg maximum.
- There are not too many grooves on the pliers in order that the given pressure is not too big. If there are too many grooves on the handle, the energy produced by the user also increases.
- The handle is coated with compressible material, like plastic or rubber so that the produced rubbing force is also optimal.
- The overall shape of the pliers’ handle is oval with the front profile in the form of a box. This is intended to decrease injury when using pliers.
- Presence of an angle on the pliers in order that the wrist is in a neutral axis. The angle is between $190 \pm 50$ to prevent occurrence of palmar flexion and dorsi flexion and ulnar deviation and radial deviation.
For the scientific calculator product:

- The main menu is arranged in order to be specifically independent, for example the on / off button. This is because the user is often not able to put on and put off the scientific calculator. The on and off buttons are each colored green and red so that the user intuitively could use mentioned menu.

- The scientific calculator’s screen is made in a large size. This is done to accommodate necessity of the elderly user. Output shown on the screen uses arial letters sized 16 pt. Besides that, the user is also able to show calculations in two-three rows on the scientific calculator’s screen.

- Usage of the symbol = for EXE and: for the division symbol. This is adjusted to the users’ need in identifying the simplest symbol for comprehension.

- Placement adjustment between buttons is according to standard. The maximum placement between buttons is 1.7 cm if calculated from one button’s centre to the other button’s centre. Whereas the distance between buttons is 0.6 cm.

- Use of menus commonly used by the user. Determination of these main menus is adjusted to need by performing interviews towards each user group.

- Buttons in rectangular shape using soft material (to be pushed) and adjustment of letter and number size. The shape of the buttons is determined based on the test results for tactile discrimination.

- Use of Braille and raised embossed letters on the speaker button and the speaker. This use of Braille is done on the lower buttons containing numbers. This is because on each button there is only one character therefore it’s possible to place a Braille letter. Whereas on the upper buttons which are smaller in size only raised embossed letters are placed with a thickness of 0.1 cm. This is because one mathematical function consists of several letter characters whereas the button’s size is quite small.

For the plastic bottle product:

- The diameter on the bottle’s body is adjusted to the length of the users’ palm. Diameter of the plastic bottle design is 8 cm with a circumference of 16 cm. When the user grips the bottle a full grip is not necessary and is assumed enough by dominating only three fourth of the bottle’s circumference. Whereupon the user’s hand size is minimum 12 cm, then the user could still hold the bottle comfortably with a diameter of 8 cm.

- Addition of a knurled contour on the grip position with a full diamond type with a span of 0.4 cm. The contour addition is also meant to prevent the hand from slipping when holding or grasping the bottle. The contour is made more spaced for a rougher effect feeling in order that less energy is needed to grasp the bottle.

- The colour of the plastic bottle is adjusted to the user’s colour choice.
The procedure of opening the plastic bottle is by turning, like all plastic bottles in general. The bottle’s type is designed because the average user understands better how to use the bottle, the procedure of opening as well as closing the bottle. The bottle’s cap, is also applied with a full rectangular contour with the purpose that the user could open the bottle easier because the contour’s thread opposes the threads on the palm.

**Figure 6: Plastic Bottle Product Design (Closed and opened Position)**

4. CONCLUSION

Based on the research results several conclusions could be drawn referring to earlier determined problem formulations. The drawn conclusions will be explained as follows:

1. From the three used family products in this research, every family product does not fully accommodate the universal design principle. Users with certain limitations frequently could not utilize the product properly therefore it could be concluded that the eleven universal design principles are not appropriately fulfilled.
2. Constraints in using the product do not only occur in the physically disabled user group, but also in the normal user group. The constraints occurring in general are similar but the constraints undergone by the user with physical limitations are much more than the normal user group.
3. A good product design characteristic should meet the universal design principle which is definitely adjusted to the needs and expectations of the user. The design of the product should also be based on the limitations undergone by each user group and also take a trade-off into account which could possibly happen.

REFERENCES


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