JURNAL ILMIAH TEKNIK INDUSTRI
ISSN: 1412-6869 e-ISSN: 2460-4038
Journal homepage: http://journals.ums.ac.id/index.php/jiti/index
doi:10.23917/jiti.v18i2.8133

Evaluation of Usability on Bionic Anthropomorphic (BIMO) Hand for Disability Hand Patient

Novie Susanto[1a], Heru Prastawa[1b], Manik Mahachandra[1c], Dinda Ayu Rakhmawati[1d]

Abstract. *One aspect that needs to be assessed to make a better product is usability. Testing the level of usability on BIMO hand is performed using an adapted Southampton Hand Assesment Procedure (SHAP) method. Users are given the task of using a prosthetic hand to perform daily activities according to performance measurement rules. Based on the opinion of Jacob Nielsen, the theory used to measure usability is 5 main parameters, i.e., Learnability, Memorability, Efficiency, Satisfaction, and Errors. Testing is done by giving 15 tasks daily activity to the respondent. After testing, respondents were given USE questionnaires (Usefulness, Satisfaction, and Ease of use) as a media for usability assessment and received suggestions from respondents. Some suggestions were obtained from the respondents after the research was conducted, such as the size of the product, censoring product respond, the suitability shape, and the weight of the product. Based on the percentage of USE questionnaire assessment known Usability Prosthetic hand level tested is in the status of GOOD, this indicates the respondents feel the product is good to use.*

Keywords. *BIMO hand, USE questionnaire, SHAP, usability*

I. INTRODUCTION

The high number of people with disabilities in Indonesia makes the health field become one of the fields that have high potential in the creation of various products tailored to the needs of users. Based on the National Socioeconomic Survey (Susenas) in 2012, the population of people with disabilities is 6,515,500 people from the total population of 244,919,000 (Kemenkes, 2013; Riskesdas, 2013). This means that as many as 2.45% of Indonesians are people with disabilities (Diono, 2014). While Survey on the Need for Social Assistance Programs for People with Disabilities (SNSAP-PWD) states about 67% of the main causes of people with disabilities in Indonesia are due to accidents, so people with disabilities need tools to carry out their daily activities (Adioetomo, 2016).

According to UU RI No. 4, 1997, disability is a term that encompasses disruption, limitations, and restrictions on participation. Disorders are a problem with the function of the body or structure. A limitation of activity is the difficulty faced by the individual in carrying out the task or action, while the restriction of participation is a problem experienced by the individual in their life situations. There are three types of persons with disabilities that are physically, mentally, physically and mentally disabled, so that people with disabilities are anyone with physical and / or mental disabilities who may interfere with or constitute obstacles for them to perform activities appropriately. UU RI No. 8, 2016 article 12 states one of the health rights for people with disabilities is the right to obtain a Medical Device based on their needs and to obtain protection in health research and development that includes human beings as subjects. While in Article 42 paragraph (3) it is explained that each higher education provider is obliged to facilitate the establishment of the Disability Services Unit.

The use of health aids is intended to improve the productivity of the patient's work. Swashta (2000) states that productivity is generally interpreted as a comparison between what has been produced and what is used. Productivity is the level of efficiency in expressing how to utilize the existing resources well.

There are many innovative tool products currently being developed in Indonesia. Diponegoro University, especially the Mechanical

[1] Industrial Engineering Department, Faculty of Engineering, Diponegoro University, Prof. Soedharto SH, Tembalang, Semarang 50275

[a] email: novie.susanto@ft.undip.ac.id
[b] email: heru.prastawa@gmail.com
[c] email: manik.mahachandra@gmail.com
[d] email: ie.dindaayu@gmail.com

Submitted: 16-05-2019 Revised: 19-11-2019
Accepted: 30-11-2019

Engineering Program in cooperation with the Industrial Engineering Program, develops tools for people with disabilities. One of the innovative product that is being developed is the Bionic Anthropomorphic Hand (BIMO HAND).

BIMO HAND is one of the tools designed and developed for persons with disabilities. It is designed in accordance with Indonesian dimensions and can be controlled for six predetermined motion patterns pre-designed by the designer. The controller used in this bionic hand is an Arduino Nano microcontroller that is driven using five servos. The materials used are PLA (Polylactide Acid) and acrylic and printed using a 3D printer. The total weight of this BIMO HAND is less than 500 grams (Oktavianto, 2017).

Research related to bionic hand evaluation has been done before by Industrial Engineering students of Diponegoro University and cooperate with the Mechanical Engineering Program of Diponegoro University. The study was conducted in the form of evaluation of Usability of Anthropormophic Prosthetic Hand product to assess the satisfaction level and fulfillment of consumer needs (Primaresky, 2017; Susanto et al., 2017), while the current research was conducted to evaluate the usability of BIMO HAND product which has different specification with Anthropormophic Prosthetic Hand.

The development of Bionic Anthropormophic Hand as one of the most active tools of handicapped persons is supporting the creation of products that match the desires of the users both in terms of dimensions and the economic side (Brey, 2005). One of the evaluations that should be done is the usability of the product. Usability evaluation is done by using USE (Usefulness, Satisfaction, and Ease of Use) questionnaire (Lund, 2001) and the adapted Southampton Hand Assessment Procedure (SHAP) method (Light et al., 2002) required to assess how far the product is made to meet the consumer's need to achieve the desired goal so that the consumer will be satisfied when using product. Other methods of usability testing are reviewed by Davis (1989), Band (1991), Dumas and Janice (1998), Jordan (1998), Bare (2002): Al-Farisi (2009); Chisnel (2008).

Recent studies related SHAP implementation show various and broad field of SHAP (Light, 2000; Light, et al., 2002; Cary & Adams, 2003; Murgia et al., 2004; Metcalf et al., 2007; Adams et al., 2008; Metcalf, 2008; Metcalf et al., 2008; Kyberg et al., 2009; Issa et al., 2009; Van der Net Otr et al., 2011; Kyberg, 2001; Van der Net Otr et al., 2013; Vasluian et al.; 2014; Fougner et al., 2014; Hermannsson et al., 2014; Dalley et al., 2014).

II. Research Method

Research Procedure

In this research, respondents will be given information in advance about the research and steps that must be done. Research is done by taking video as a tool for measuring the time and documentation of the research when the respondents do the task given. The data of the research were collected for the Usability analysis of the Anthropomorphic Prosthetic Hand product. The results of the analysis are then used as the basis for proposing the improvement.

Data Collection and Analysis

Data collection in this research is done by two methods, and there was a qualitative and quantitative method. The data obtained by measuring the assessment criteria that have been done previously. At this stage, measurements and interviews are conducted by experimenting with handicapped persons with disabilities. The patient is instructed to perform some activities using the BIMO HAND. The work done is a standard daily activity determined by the SHAP (Southampton Hand Assesment Procedure) including: (1) take a coin, (2) removing various types of shirt buttons, (3) cut food with a knife, (4) flip the paper, (5) open

Figure 1. Measurement by respondent

the bottle cap, (6) pouring water from the kettle into a glass, (7) pour water from the carton packaging into a glass, (8) lifting a heavy (cylindrical) object, (9) lifting objects (cylinders) lightly, (10) move the tray or tray, (11) turn the key, (12) open and close the zipper, (13) turn the screw, (14) open the door with the handle.

The examples of data collection carried out can be seen in Figure 1. Assessment in each criterion is carried out by the procedure as follows:

a. Memorability. Measuring the level of ease to remember is done by repeating the tests carried out with the same task on the respondent without prior instructions. This is performed to measure how easy the procedures and steps of BIMO HAND work have been done before.
b. Errors. Measurement of errors is done by looking at how the respondent did the assigned task. By giving instructions to the respondent first about the workings and types of tasks to be carried out, then the respondent was asked to experiment according to what was previously instructed. The error rate can be seen if the activities carried out by the respondent are not in accordance with the instructions given, or the respondent does something outside the experiment.
c. Efficiency. To measure the level of efficiency in this experiment, time measurements were taken from respondents when working on the task. From the results of these measurements later, the time of the respondent when conducting the experiment will be compared with normative time data based on Light (2002) research with the same task execution.
d. Learnability. The level of ease of learning from BIMO HAND products is done by conducting interviews with respondents. Questions were given to respondents according to the list of questions contained in the USE questionnaire. Respondents will then be asked to give a score on the ease of product to learn.
e. Satisfaction. Measuring the level of satisfaction of BIMO HAND users is done by conducting interviews shortly after the respondent conducts the experiment. Questions raised to respondents refer to the USE questionnaire. Respondent satisfaction gauges are carried out using the scale contained in the questionnaire.

After the experimental observations and interviews were conducted to obtain the data directly, the next step is to recapitulate the data obtained. In this section, the data obtained from the measurement of the resource is examined more deeply and adapted to the theories obtained during the literature study. The results of the questionnaire were later be adjusted with the Usability level as classified in Table 1.

Table 1. Usability level (Nielsen, 1993)

Usability Level	Point
Bad	0-20%
Poor	21-40%
Moderate	41-60%
Good	61-80%
Excellent	81-100%

Respondents

Respondent in this study was someone who experienced a shortage of limbs or persons with special disabilities. Respondents in this study were Mr. Muhammad Idris Harahap, 27 years old with a weight of 65 kg, and a height of 168 cm. Retrieval of data on respondents is custom and very limited in number because bionic hand installation also requires a bionic hand connecting socket with the respondent's body parts designed custom depending on the type of disability.

III. Result and Discussion

USE Questionnaire

After all, the experiments were done, and the questionnaires were filled by the respondents, the data from the USE Questionnaire were recorded, and the percentage of respondents' assessment was calculated with the maximum value that could be obtained from the questionnaire. In total, there are 30 questions in the USE Questionnaire with the maximum value for each question is 7. Respondents are asked to fill opinions on the scale of numbers 1 to 7 in accordance with respondents' perceptions of each question in the questionnaire. The result of the percentage of assessment in the questionnaire will then be adjusted to the Usability Level to see the Usability status of BIMO HAND.

Learnability

There were 11 questions in the USE questionnaire that were related to the Learnability aspect. The results of filling out the questionnaire are shown in Table 2.

Table 2. Learnability Test Result

Activities	Total %
Move the ball	71.43
Move Triangle	82.14
Move the tube	71.43
Moving a Tip Item	85.71
Moving Extension Objects	85.71
Pick up Coins	57.14
Removing various types of shirt buttons	50.00
Flip the paper	82.14
Open the Bottle Cap	46.43
Pouring Water from the Teapot to the Glass	75.00
Pouring Water from the Carton to Glass Packaging	60.71
Lifting Heavy Objects (Cylinders)	82.14
Lifting Lightweight Cylinders	85.71
Turn the Lock	67.86
Open the Door with a Handle	92.86
Average	**73.10**
Status	***Good***

The biggest value is obtained in the process of opening the door with a handle of 92.86%. This activity is quite simple and does not require special skills. The lowest value was obtained in the process of opening the bottle cap by 46.43%. The process requires the respondent's skill to bend the elbow so that the bottle cap is easily opened, while the respondents find it difficult to bend the elbow due to the use of sockets.

Memorability

Measurements are made by looking at how easily respondents remember the procedure for using BIMO HAND starting from the beginning of each task given. Data was obtained when the respondent made a step error in carrying out the task given. Data on the observation of the level of memorability show that only coin move activity failed due to steps that are more than other task procedures. Other activities were successfully performed by the respondent.

Errors

Errors rates are obtained through observation when the respondent performs the entire task that has been determined. Observations were made to see whether when doing a task, there were errors or things that were not in accordance with the instructions. The highest error value is found in the task of moving the triangle. The fact shows that during the data collection process, the respondents dropped the triangle-shaped object twice. This is due to the power of the handheld BIMO HAND in Tripod mode is small, and it makes difficult to move the object. In addition, respondents also feel uncomfortable because the surface of the finger feels slippery.

The next level of error comes from the task of pouring water from the carton pack into a glass and releasing various types of shirt buttons. When the respondent poured water from the carton pack, the error occurred after the water was finished pouring. According to the procedure, after the water has been poured, the respondent must return the carton packaging to its original position. In one experiment, it was seen that when returning the cardboard package to its original position, the BIMO HAND relaxation process did not work. This kept the carton packaging in the palm of the hand and could not be removed.

When the respondent released various sizes of shirt buttons, the respondent could not remove the buttons of the smallest shirt from the hole. This is because there is a gap between the fingers on the BIMO HAND so that the process fails.

Satisfaction

In this study, the level of satisfaction of product use was obtained by providing USE questionnaires to respondents after each task was given. In the USE questionnaire, there are seven questions about respondents' assessment of product satisfaction levels, where each question has a maximum value of 7. Table 2 below is a product satisfaction data from respondents

Recapitulation data and questionnaire calculations are shown in Table 3.

Efficiency

The efficiency criteria in this study are described by the time needed by the respondent to complete a given task. Time measurement is done when the respondent tests the BIMO Hand.

The completion time begins when the respondent interacts with the object until the respondent completes the task according to the instructions given previously. Measurements were made for each task and as many as five repetitions. From the measurements taken, the testing time is obtained for each task, as shown in Figures 2-16. Data from the recapitulation of time when the respondent did the task of moving a spherical object was very volatile.

Table 3. Satisfaction Test Result

Activities	Total %
Move the ball	63.27
Move Triangle	65.31
Move the tube	65.31
Moving a Tip Item	79.59
Moving Extension Objects	79.59
Pick up Coins	46.94
Removing various types of shirt buttons	53.06
Flip the paper	83.67
Open the Bottle Cap	61.22
Pouring Water from the Teapot to the Glass	57.14
Pouring Water from the Carton to Glass Packaging	65.31
Lifting Heavy Objects (Cylinders)	67.35
Lifting Lightweight Cylinders	79.59
Turn the Lock	67.35
Open the Door with a Handle	85.71
Average	**68.03**
Status	**Good**

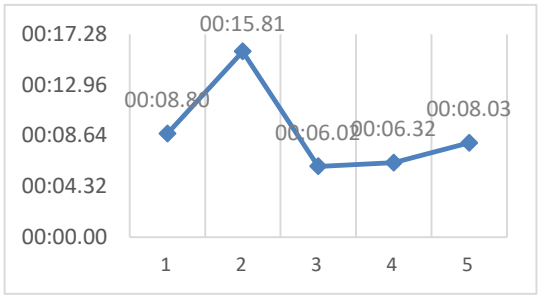

Figure 2. Time Chart for Moving a Ball

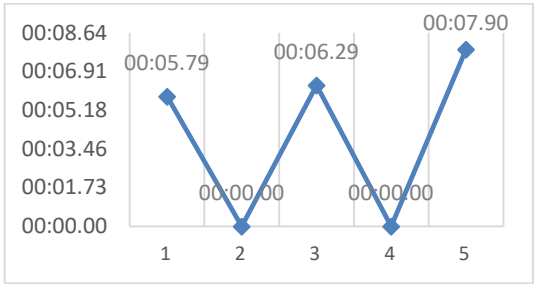

Figure 3. Time Chart for Moving Triangle

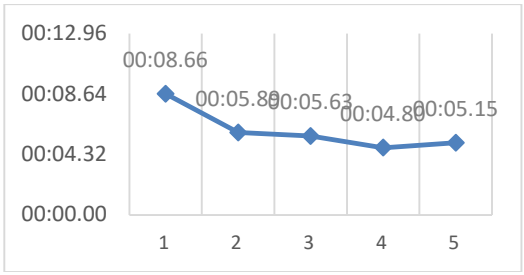

Figure 4. Time Chart for Moving Tube

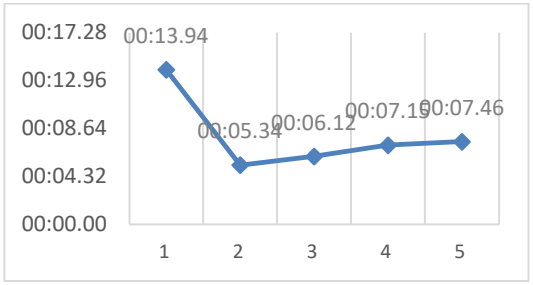

Figure 5. Time Chart for Moving Tip Object

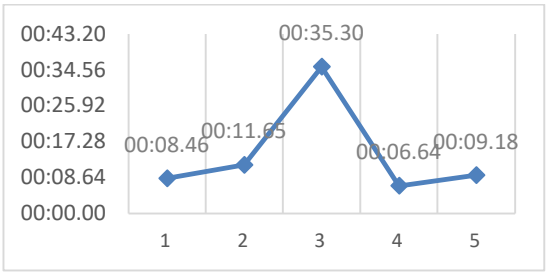

Figure 6. Time Chart for Moving Extension Object

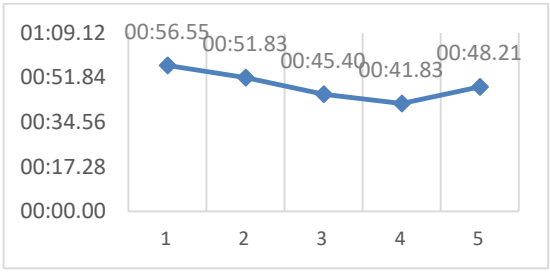

Figure 7. Time Chart for taking coins activity

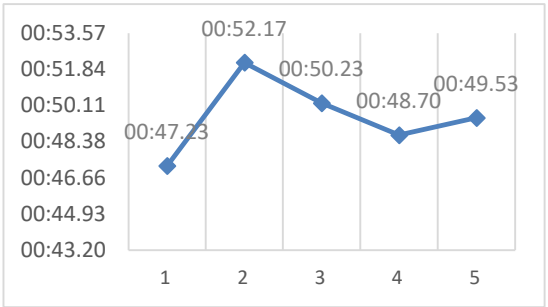

Figure 8. Time Chart for Removing various types of shirt buttons

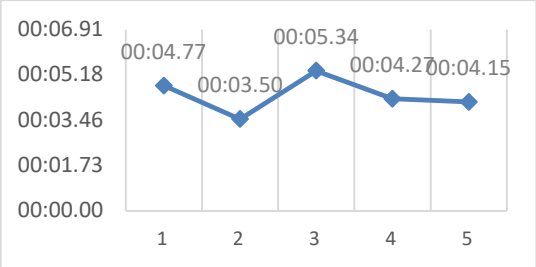

Figure 9. Time Chart for flipping paper activity

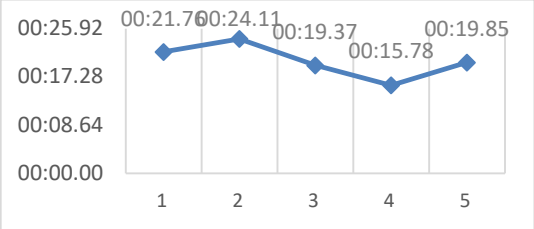

Figure 10. Time Chart for opening the bottle cap

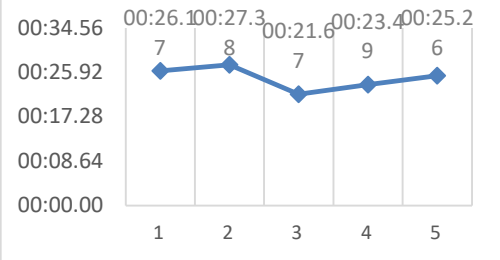

Figure 11. Time Chart for Pouring Water from the Teapot to the Glass

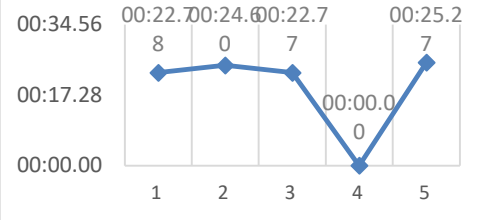

Figure 12. Time Chart for Pouring Water from the Carton to Glass Packaging

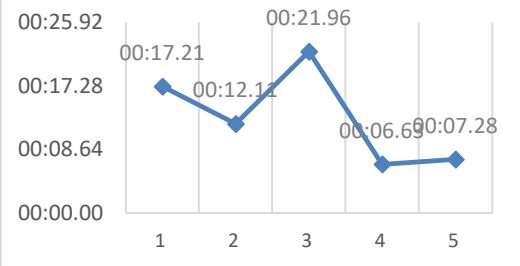

Figure 13. Time Chart for Lifting Heavy Objects (Cylinders)

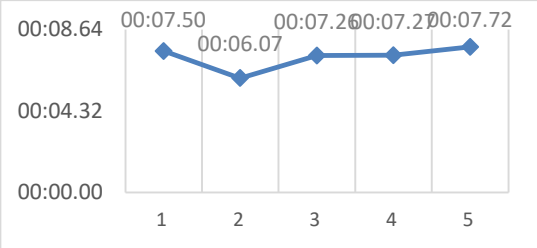

Figure 14. Time Chart for Lifting light Objects (Cylinders)

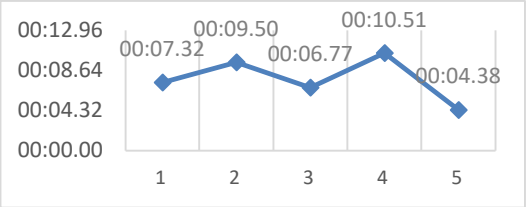

Figure 15. Time Chart for turning the key

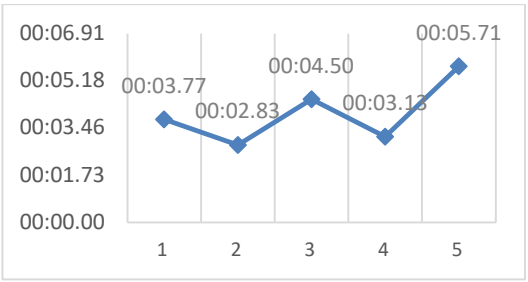

Figure 16. Time Chart for opening the door with the handle

Table 4. Result of USE Questionnaire Percentage

Criteria	Percentage (%)
Usefulness	59.52
Ease of Use	64.07
Learnability	73.10
Satisfaction	68.03
Total Usability Level %	66.18
Status	***Good***

The "Good" status indicates the respondent feels quite satisfied when using the product. However, there were some difficulties in completing the task that has been given. For example, the respondent argues when contracting BIMO HAND, the product does not work according to what is desired. The same thing happens when the respondent gives a signal of relaxation to the product, but the product does not immediately

Table 5. Incident Diaries Results for Unable Tasks

No	Activity	Reasons	Recommendations
1	Moving lateral object	The mass of the object is too large; BIMO's hands are not strong to withstand the load.	The load of BIMO hand is enlarged to 1 kilogram because it does not match the initial specification
2	Lifting a tray	The tray moving process requires two hands, in which the minor hand is in charge of holding the load when the major hand lifts the tray. The minor hand of the respondent can not be used so that the moving activity can not be done.	-
3	Open/close zip	a. There is a large gap between the thumb and forefinger, so the zipper hook can not be reached. b. The size of the radius is less suitable with the existing zipper design.	a. The Degree of Freedom (DOF) thumb width is enlarged, so the tip of the thumb and forefinger can meet. b. The size of the radius is adjusted to the Indonesian anthropometric data, or patient data.
4	Rotate a screw	a. There is a gap between the fingers, so the grasping process can not be done perfectly and the screwdriver can not be lifted properly. b. Screwdriver always slips due to the type of material used.	a. The width of the finger opening is magnified. b. PLA material replacement with ABS material.
5	Simulated food cutting	a. BIMO's hand strength is small, so it can not cut the food (plastisin). b. There is a gap between the fingers, so the grasping process can not be done perfectly, and the knife can not be lifted properly.	a. The power of the finger grip is enlarged to 1 kilogram. b. The width of the finger's DOF is magnified.

react to release the object held. Respondents felt in The need to add a few hinges and adjustments to the hand to make it easier for users to do some activities. The summary of an efficiency test result can be seen in Table 4.

The greatest score was found in the 73.10%, which is because respondents find it quite easy to learn the use of BIMO HAND without written usage instructions. Respondents feel great when using BIMO HAND so that the feeling encourages respondents to learn and accustomed more quickly to adjust to the product. The smallest value given by the respondent is on the Usefulness criteria that is equal to 59.52%. The assessment is given by respondents because respondents do not feel the benefits of BIMO HAND in completing some tasks; it takes a lot of position adjustment and usage method to complete the task given. Besides, the respondents felt limited movement while using the product. These problems make the respondent feel uncomfortable and give enough value to the usefulness criteria.

From the results of the assessment recapitulation, the percentage value will be averaged to get the final percentage of BIMO HAND Usability rating. Once the final result is obtained, the results will be adjusted to the Usability Level to see the final status of the product when used. From the interviews with the respondents, researchers found some problems experienced by respondents, including the slippery hand surface, the strength of hands to grip the goods, the lack of flexibility of the hands until the response time of the BIMO HAND. From the recapitulation, the final average assessment of respondents is equal to 66.18%. These results then adjusted to the Usability Level so that it shows the status of 'Good'. These results show that

Tabel 6. Incident Diaries Results for Possible Activities

No	Activity	Reasons	Recommendations
1	Moving Spherical object	-	-
2	Moving tripod object	a. BIMO Hand Hands power for tripod mode is small. b. The surface of the finger is slippery.	a. The DOF of the finger is magnified. b. Replacing PLA material with ABS.
3	Moving cylinder object	a. The relaxation process is not working well.	a. Routine exercise is required. b. Sensors should be made specifically so it would not disturb the users when the product is used.
4	Moving Tip object	-	-
5	Moving Extension object	The relaxation process is not working well.	Sensors should be made specifically so it would not disturb the users when the product is used.
6	Pick up coins	a. The surface of the finger is slippery. b. The hand response is delayed. c. Respondents have difficulty in balancing the strength of their hand muscles.	a. Replacing PLA material with ABS. b. Hand censor replacement.
7	Button board	There is a large gap between the thumb and forefinger, so the buttons can not be removed.	The DOF of the finger is magnified.
8	Page-turning	Respondents found it difficult to flip the paper because the wrists could not be moved.	Changing the motions mechanism.
9	Jar lid	Respondents had difficulty in regulating the strength of their hands and BIMO's hand to open the bottle cap.	Enlarging the load of BIMO Hand.
10	Glass jug pouring	a. Respondents had difficulty adjusting BIMO's hand movements to pour water. b. The strength of respondents' hands is small enough that the existing water mass should be reduced.	a. Improving the motion mechanism. b. Enlarging the load of BIMO Hand.
11	Carton pouring	The relaxation process is not working well.	a. Routine exercise is required. b. Sensors should be made specifically so it would not disturb the users when the product is used.
12	Lifting a heavy object	The relaxation process is not working well.	a. Routine exercise is required. b. Sensors should be made specifically so it would not disturb the users when the product is used.
13	Lifting a light object	The relaxation process is not working well.	a. Routine exercise is required. b. Sensors should be made specifically so it would not disturb the users when the product is used.
14	Rotate key	-	-
15	Door handle	-	-

respondents give a good response to the use of the product with some shortcomings that need to be improved.

Incident Diaries

Incident Diaries is a form of inquiry where Users record their level of experience with a product. Incident Diaries in the form of mini questionnaires given to respondents in order to record any problems experienced when using the product. The questionnaire consisted of seven questions, covering the whole series of activities and things that occurred during the experiment, the effect of the product on the respondent, the observer's view of the product, the effect of the product on the experimental model, how something in the experiment could happen, how to avoid mistakes errors in future experiments, and how to meet user needs for product usability (Jordan, 1998). Table 5 and Table 6 describe the

Incident Diaries data recap based on observations by respondents and observers. There are 5 tasks that can not be done during the experiment. The reason why these five tasks can not be done is listed in Table 5 above. Meanwhile, as many as 15 other testing activities can be performed during the experiment. Table 6 illustrates the Incident Diaries for 15 possible testing activities.

IV. CONCLUSION

Measurement of usability level is done by presenting the results of filling out the USE Questionnaire, which has been assessed based on the respondent's perception after using the product. The final percentage is the result of the average calculation of all usability criteria in the questionnaire, which are learnability, memorability, errors, satisfaction, and efficiency. Test results that have been adjusted to the usability level indicate BIMO HAND products are in good status, can be drawn the conclusion based on the results of the respondents gave a good response to the use of products with some notes and feel BIMO HAND products are good for use by improving the functionality and comfort of the product. After conducting the research by conducting BIMO HAND test on the respondents to do some task, brainstorming was done to identify the factors that influence the ease of use of BIMO HAND according to the respondent's perception. The result of identification of these factors is a product that is considered slippery when used to take some objects, less powerful grip when used for the process of grasping, the gap between the fingers that resulted in the fingers less tightly to clamp a small or thin objects, less suitably hand size, shape too stiff palms, lack of flexibility in the wrist joints, too heavy product mass, and features/modes used are less variable. The results of brainstorming are then used as input for the next BIMO HAND model improvement. Evaluation and design of proposed improvements are formulated so that the product more in accordance with the needs and wishes of potential users.

ACKNOWLEDGEMENT

This research was financially supported by Diponegoro University (SUMBER DANA SELAIN APBN DPA LPPM UNIVERSITAS DIPONEGORO) in RPP (Riset Pengembangan dan Penerapan) scheme (2019). This research also in-kind supported by PUI-PT CBIOM3S Diponegoro University.

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