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DESIGN OF ERGONOMIC STOOL (DINGKLIK) FOR BATIK CRAFTERS

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ABSTRACT
Batik crafting is a job done in a sitting position. The design of a stool itself affects the sitting position of workers using it. This paper proposes an optimal design for batik stool (dingklik) which is tested using the task analysis toolkit in the virtual environment with the JackTM 6.1 software. An anthopometric measurement is done to create the suitable dimension for all users of the batik stool. This research is conducted to reduce MSD found in previous research, by designing ergonomically friendly stool to support batik crafters. This improved design is proved to be ergonomically friendly due to the decreased PEI result compared to the current design.

Keywords: Batik; Dingklik; Ergonomics; Product design

1. INTRODUCTION
Batik crafting is done by repetitively pouring malam (a liquid wax) using an equipment called canting (Figure 1). To hold the batik sheet, batik crafters use gawangan (batik stand). For melting the wax (malam) the crafter uses a small stove and a frying pan. Batik crafters work using dingklik (traditional stool), a short-sized stool which has no backrest to sustain the correct of torso posture, this equipment would give a particular effect to the body posture, which will be dicussed in this paper. There are two main positions in batik crafting which are mencanting (painting the batik) and reaching out for the wax, which is used as the main position of crafting batik through out this research.

Figure 1 Canting used to paint wax

The design of a stool affects the sitting position of workers using it. Static sitting posture can potentially cause the occurrence of *musculoskeletal disorders* (MSDs) up to 50% (Hedge, 2009). This risk is even higher for the people aged 20 to 45 years old. This also occurs to majority of batik crafters (67.7%), which experienced *musculoskeletal* fatigue, especially in the neck, right shoulder, waist and bottom (Widyaningsih, 2009).

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This research is conducted to reduce MSD found in previous research, by designing ergonomically friendly stool to support batik crafters.

2. METHODOLOGY

The working position of *mencanting* (painting the wax) and reaching out for the wax is used to calculate the optimal stool design. In order to make the design ergonomically friendly, a anthomometric measurement is done in Kampung Laweyan, Solo, Central Java. The sample of this research is 37 female batik crafters in five Small-Medium Enterprises in Kampung Laweyan.

Currently batik crafters use a stool with out a backrest shown in Figure 2. From the measurement the average stool used is 23 cm-high, 26 cm-wide and 22 cm-long. A research found that a person sitting in a 20 cm-high stool for 16 minutes will have a higher level of discomfort compared to the 10 cm and 15 cm-high stool. Thus, this average stool dimension for batik crafting is indicated as one of the cause of musculoskeletal disorders faced by crafters. This sitting position have big potential in rising the injury occurrence of WMSD (Work Musculoskeletal Disorder) and fatigue on workers. All calculations in this research is using a constant view distance of 30cm to the batik sheet hung on the *gawangan* and the a 30cm-high of the stove.

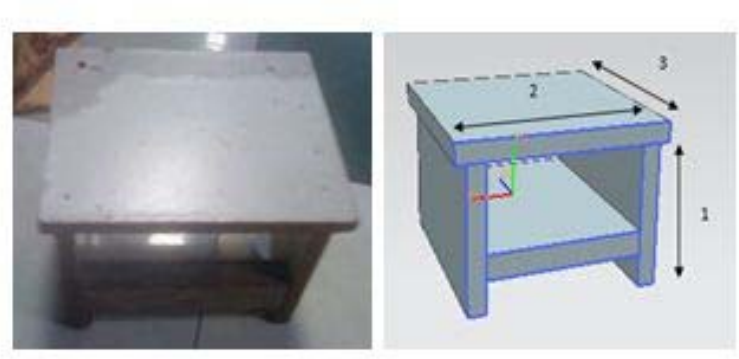

Figure 2 Current batik stool used; 1: height, 2: width, 3: length

The questionnaire and direct observations done on this current situation, also strengthen the assumption that the stool is not comfortable for an everyday use. Figure 3 shows that with the current equipments most musculoskeletal disorders occurs on the right shoulder, upper back, upper arm right, right forearm, buttocks, right foot and left foot. This result proves that there is a work posture problem faced by batik crafters because of the current design of equipments, in this case the stool.

To design an ergonomically friendly stool, an athopometric measurement was done. The designing method of this stool is using a design for extreme principal. Design for extreme is used to accommodate majority of people using the stool. This method uses the 95-percentile and 5-percentile of the anthopometric data. The 5th and 95th percentile determined is assumed to cover the entire population. The measurement needed to develop this design is as follows:

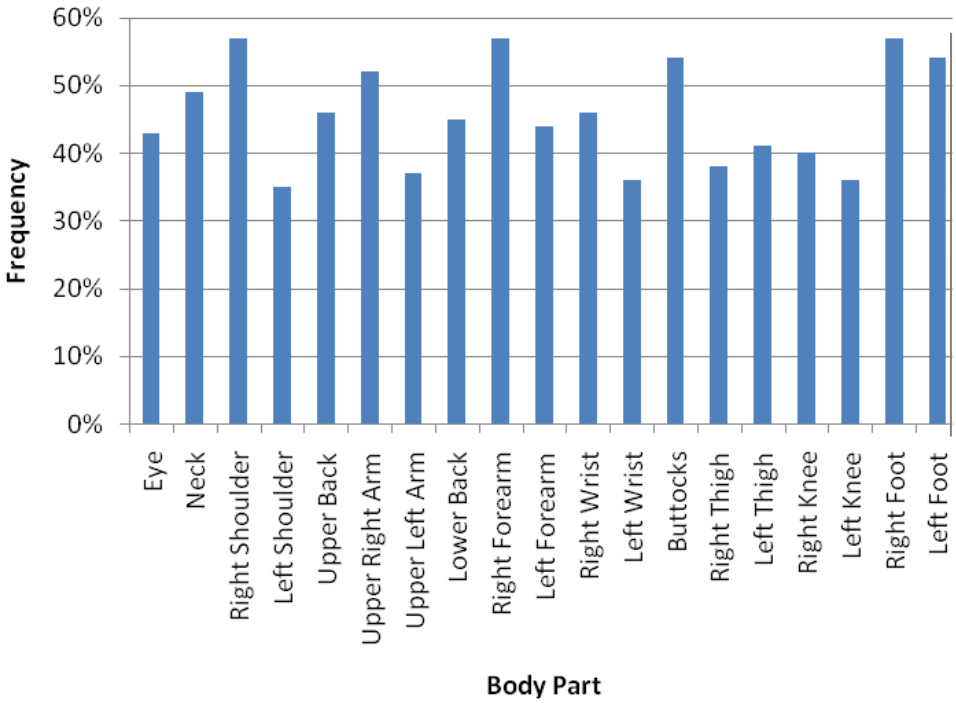

Figure 3 Frequency of musculoskeletal complaints on body parts

1. Stool height
   This measurement is using the 5-percentile anthopometric data, because it is assumed that if the people in the lowest percentile could place there feet on the ground, so does the people in the highest percentile. This mesurement is using the popliteal height of the body.
2. Stool length
   The stool length is made using the anthopometric measurement of buttock popliteal length. The data used is the 5-percentile data, to assure all users could lean back optimally.
3. Stool width
   This dimension is made using the measurement of a 95-percentile worker. The stool width is made to be able to support the hip of all users. Because of this the longgest hip breath measurement is used. This measurement is given a 10% allowance to increase the comfort of this stool.
4. Backrest height
   The backrest used is a medium-level backrest which could support the upper back and shoulder. The height of a medium-level backrest is 60–80% of the human shoulder height, which 80% is used in this design. To be able to support all users, the highest percentile is used for this measurement.
5. Stool and backrest angles
   The tilt angle of the backrest is based on the optimal tilt level that is 100^{o}–110^{o} (Pheasant, 2003). The 100^{o} tilt is used in this design to ensure the body position is more stable especially for elderly people. The backrest that is tilt 100 degrees forces the neck to make form a 30 cm viewing distance. This position will automatically make a change in the neck-head angle 10 degrees downwards. For the seat itself, its the optimal angle suggested is 5–10^{o} (Pheasant, 2003). In this case the design uses 5^{o} as the optimal angle

for the seat.

6. Armrest height
   The height armrest must support the lower side of the arm but is not allowed to injure the elbow is sensitive. The backrest must have a 10 cm distance to the armrest to avoid that injury (Pheasant, 2003). The height of the armrest itself uses the elbow sitting height. This measurement will use the 5-percentile height so the people in this percentile would not have to raise their arm to use this armrest.

The current design and improved design are analyzed using an ergonomic scale with Static Strength Prediction (SSP), Lower Back Analysis (LBA), Ovako Working Analysis System (OWAS) and Rapid Upper Limb Assessment (RULA) which is then evaluated using a Posture Evaluation Index (PEI). The results of the improved design is then compared to the current design to prove that it is ergonomically friendly. These ergonomic test is also done to prove the proposed design reduces MSD effects on batik crafters.

3. RESULTS AND DISCUSSION

The anthopometric data was collected and tabulated in Table 1. This data is normally distributed using 5%-level of significancy. A reability test was also done to validate the data. From the test, it shows that the value of Cronbach's Alpha is 0.893, which show that it is reliable. A Kolmogorov–Smirnov statistic test was also done to show that the sample is drawn from the reference distribution of anthopometric measurements.

Table 1 Anthropometric measurements data (cm)

No.	Measurement Component	Percentile	
		5%	95%
1.	Height	155.21	159.10
2.	Weight	44.16	59.29
3.	Sitting height	75.35	81.67
4.	Eye height	63.28	69.90
5.	Shouder height	51.54	58.17
6.	Elbow rest height	18.55	26.89
7.	Thigh clearence	11.62	16.61
8.	Popliteal height	36.11	42.11
9.	Knee height	43.86	50.78
10.	Buttock popliteal height	37.61	44.12
11.	Hip breadth	28.31	34.18
12.	Knee-to-knee breadth	21.59	27.49
13.	Vertical grip reach	110.35	118.50
14.	Foot length	21.33	23.79

The 5^{th} and 95^{th} percentile measurement was selected because these two measurements are needed to complete the dimensions (Table 2) of the ergonomically friendly stool shown in Figures 4 and 5.

Table 2 The dimension of the improved stool

No.	Measurement Component	Anthropometric Data Used	Percentile	Dimension
1.	Stool Height	Popliteal Height	5	36 cm
2.	Stool Length	Buttock Popliteal	5	37.5 cm
3.	Stool Width	110% of Hip Breadth	95	38 cm
4.	Stool Angle			5^{o}
5.	Backrest Height	80% of Shoulder Height	95	46.7 cm
6.	Backrest Width	(as seat width)		48 cm
7.	Backrest Angle			100^{o}
8.	Armrest Height	Sitting Elbow Rest Height	5	18.4 cm
9.	Armrest distance from backrest			10 cm

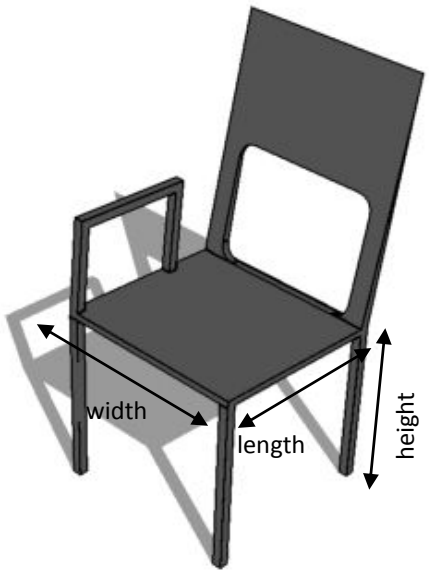

Figure 4 3D sketch of the improved stool design

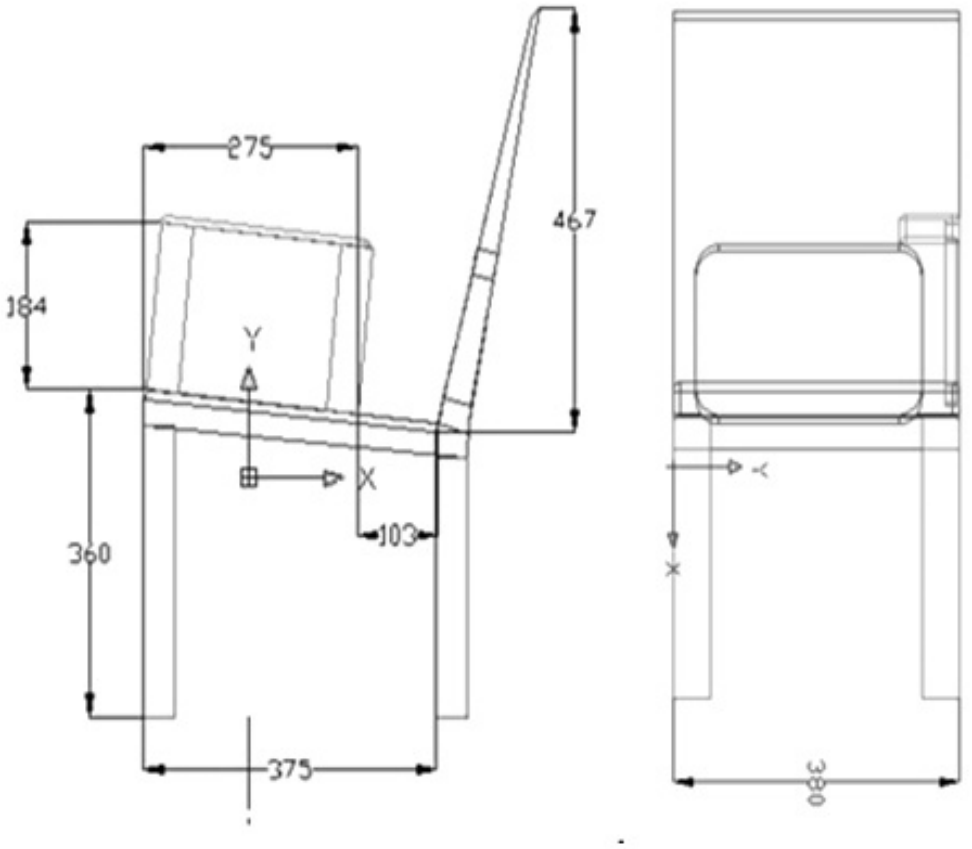

Figure 5 2D sketch of the improved stool design (mm)

This improved design (Figures 4 and 5) is proven to be more ergonomic friendly by the decrese PEI score compared to the current situation. The current PEI score for the 5-percentile workers using the current stool in *mencanting* is 2.166 for batik crafting with bent legs, which is slightly lower than the position with straight legs with 2.202. The PEI score for the proposed design is 1.399. This result shows that it is more comfortable for 5-percentile workers to use the improved design. This new design is also a good option for the 5-percentile workers in the reaching wax activity. The current PEI score is 2.428 for the reaching wax position with straight legs while for the bent legs position the PEI score is 2.247. The PEI score is much lower for the proposed design which is 1.818.

This result is nearly the same for the 95-percentile workers. In *mencanting* the PEI result is 2.123 for the position with bent legs and 2.230 for the position with straight legs. The proposed design's PEI is much lower with 1.164 for the new design. This shows that it is also more comfortable for the 95-percentile workers to use the proposed design for *mencanting*. Currenlty, the PEI result for the reaching wax activity is 2.429 for workers who craft batik with bent legs and 2.247 for workers who craft batik with straight legs. This PEI score could be lowered if the new design is used, with the PEI score only 1.504. This proves that the new design is also suitable for the 95-percentile workers.

4. CONCLUSION

- The recommended design for dingklik (batik stool) is 36 cm-high, 37.5 cm-long and 38 cm-wide, with a 5^o angle from the horizontal surface. To this stool is also added a backrest that is 46.7 cm-high that is tilt 100^o. A 18.4 cm-high armrest is also added to support the arm in crafting batik.
- The improved stool design is more ergonomically friendly for batik crafters. This is proved with the decrease in PEI result for both the 5-percentile and 95-percentile.

5. REFERENCES

Corlett, N., Wilson, J., Manenica, I., The Ergonomics of Working Postures, Taylor & Francis, London, QQ 44-53.

Hedge, A., 2009. Ergonomic Seating? Cornell University.

Keyserling, W.M., Donoghue, J.L., Punnet, L., Miller, A.B., 1982. Repetitive Trauma Disorders in the Garment Industry Report No. 81-3220, Department of Environmental Health Sciences, Harvard School of Public Health, Boston.

Pheasant, S., 2003. Bodyspace: Anthropometry, Ergonomics and Design of Work, Taylor & Francis, London.

Siemens PLM Software Inc., 2008. Jack Analysis Toolkit.

Widyaningsih, V., 2009. Monitoring dan Evaluasi Keluhan Muskuloskeletal dan Sikap Kerja pada Perajin Batik Tulis di Batik Brotoseno Kecamatan Masaran Sragen, Digital Library Universitas Sebelas Maret.