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An Insight into the Mathematical Thinking of the Malay Songket Weavers

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Abstract

Songket being one of the beautiful traditional crafts of the Malays and appreciated for its aesthetics values and motifs, is hand weaved by the perseverant and patient weavers. There is so much mathematics used in the process of weaving without them putting any thought about the mathematics principles underlying the process. This paper discusses the mathematical thinking of the weavers in the process of songket weaving. Identified from the observations and the interview sessions done on the weavers are some of the basic mathematical concepts such as transformations, measurement and estimation, accuracy and equality.

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1.   Introduction

Ethnomathematics is a research discipline that explores the relationship between mathematics and culture. The ethnomathematics founding father, D'Ambrosio & Ascher (1994), describes ethnomathematics as the study of different forms of mathematics that arise from different modes of thought. He is particularly interested in the nature of mathematical knowledge among different cultures, and its relation to history of mathematics, philosophy and cognition. Alan Bishop (1988) identifies six mathematical activities common to every culture: counting, measuring, locating, designing, playing and explaining. This notion is supported by the findings obtained from ethno mathematics studies conducted with various cultural groups throughout the world (Ascher, 2002; Shaharir, 2001; Muhammad Alinor, 2007; Abdul Razak, 2000, Mat Rofa, 2007). These studies concur that mathematics is not culture free and mathematical ideas are incorporated and culturally embedded in the games, the artifacts, the music and the daily activities of all the cultures studied.

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Malaysia is rich with beautiful traditional crafts full of aesthetic values such as weaving, word carving, silverwork, weapon making (*keris*), pottery, kite making (*wau*), puppets (*wayang kulit*) and etc. Producing those crafts requires special knowledge and skills. The existence of mathematical thinking underlying the production of the beautiful art crafts produced by the Malays are rarely discussed or appreciated. This study seeks to describe an ethnomathematical study on the Malays in producing one of their precious handicrafts; the intricate and luxurious *songket.*

Songket comes from the Malay word *menyongket* (or menyungkit) which means 'to lever up' or to pick the patterns by inserting a fine *lidi* or bamboo (Figure 1) (Halimaton, et al., 2009). *Songket* is the Malaysia's 'queen of textile art'. The designs and motifs in the *songket* fabric not only portray the weaver's special skill but it also captures the Malay's cultural identity, civilization and aesthetics. Using a technique that is hundreds of years old, *songket* is woven on a foot operated wooden frame using what is commonly referred to as the supplementary weft method, a decorative weaving technique in which extra (supplementary) threads 'float' across a colourful woven ground to create an ornamental effect. In the *songket* weaving process, the supplementary threads are metallic; traditionally gold or silver thread but nowadays varieties of other metallic colours such as lime green, turquoise blue, purple, pink are also used. They are inserted in special lengths called weft 'floats' (*tekat*) in between the crosswise silk weft threads (*benang pakan*) of the main longitudinal silk warp threads (*benang loseng*). The metallic weft 'floats' are passed over and under a certain number (*tekat 3 or tekat 5*) of carefully counted silk warp threads on the loom to produce patterns that contrasts in colour and texture with the ground cloth. It is the use of these metallic threads that gives *songket* its exquisite beauty (Yayasan Tuanku Nur Zahirah, 2008).

Figure 1: A traditional weaver weaving on the traditional loom and '*menyongket*'

This study intends to explore the mathematical ideas of the weavers derived from the *songket* weaving techniques and the mathematical thinking underlying the patterns formations. Transverse symmetry is one of the techniques use in the weaving process (Norwani, 2002). According to D'Ambrosio & Ascher (1994) weaving involves geometric visualization. The weavers express the visualization through actions and materials. It requires the creation and conception of patterns, and knowing what techniques and colours to be used in the weaving process so that the patterns will emerge. Most probably, the weavers themselves, especially the older generations, are not aware of their use of the geometrical elements or the applications of the mathematical concepts in the designing and the weaving of the *songket* patterns.

Traditionally, costumes made of *songket* are worn by the royal families and dignitaries during official ceremonies and function and by bridal couples on their wedding days. Today *songket* is gaining its due recognition in the society, at both domestic and international level. *Songket* is not only used as the traditional attire in special functions and weddings, but it is also used as decor items, accessories, handbags, home gifts, etc. (Figure 2) (Yayasan Tuanku Nur Zahirah, 2008). As what was observed during the *Hari Kraf Kebangsaan 2010, 24 Feb – 8 Mac 2010* (National Craft Day), handwoven *songket* has also been getting a makeover in terms of the design (contemporary motifs and colours), material (light-weight *songket* made of silk, organza and crepe) and usage (fashion wear, shawls, home furnishing, etc.). The modifications that had been done to *songket* weaving are mainly on the technique of dyeing and production but the weaving equipment and weaving technique are still the same (Ngo, 2007).
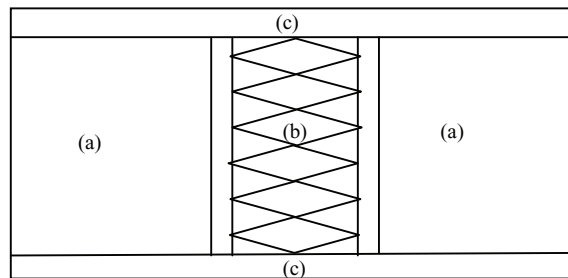
(a)	(b)	(c)	(d)

Figure 2: Songket products from YTNZ

1.1   Basic Structure and Pattern Arrangement in Songket

The basic structure of *songket sarong* and *sampin* (Figure 3) consists of
   (a)   The 'body' or the main part of the cloth (*badan kain*)
   (b)   The 'head' or the panel of the cloth (*kepala kain*)
   (c)   The 'foot' or the border of the cloth (*kaki kain*)

Figure 3: Basic Structure of *Songket Sarong and Sampin*

Generally *songket* can be classified into these main types of pattern: overall or full pattern *(songket corak penuh)*, spotted or scattered pattern (songket corak bertabur), stripes *(songket corak berjalur),* chevron *(songket corak siku keluang)*, checks *(songket corak tapak catur)* and bamboo shoot pattern *(songket corak pucuk rebung)*.

1.2   Songket Motifs

Most of the traditional weavers live in the rural villages, close to nature; hence they capture the beautiful design in their environment and incorporate them as motifs and patterns in their work. There are more than hundred motifs. Most of the motifs in *songket* are designed and named after
- the flora and fauna of their environment (ex: *bunga cengkih* (cloves), *bunga tampuk buah kesemak* (corolla of persimmon fruit), *bunga tampuk manggis* (corolla of mangosteen) and *pucuk rebung* (bamboo shoot))
- the animals kingdom (ex: *gigi yu* (shark's teeth), *rantai dada lipan* (centipede's chest chain), *lawi ayam* (cockerel's tail feathers), *rantai unduk-unduk* (a chain of sea-horse))
- the activities around the village (ex: *bunga tiga dara* (three maidens), *tapak catur* (chess board), *bunga pitis* (a square-shaped Kelantenese coin))
- the moods and temperaments of nature (ex: *awan larat* (trailing clouds), *teluk berantai* (bays or lagoons along the coastline or curves in rivers), *jong sarat* (the well-laden junk))
- the world of beliefs and the cosmos (ex: *lidah bota* (the demon's tongue), *bunga semangat* (inspirational flower), *bintang beralih* (the changing star), *bunga sinar matahari* (flower of sunshine))

- the Malay cakes and sweetmeats (ex: *bunga potong wajik* (diamond-shaped cake of glutinous rice), *bunga tepung talam* (also a diamond-shaped cake), *bunga madu manis* (honey sweet cake))

Animal motifs are highly stylized and modified because the Malays are Muslims and Islam discourages a realistic portrayal of animal and human figures in art. Most *songket* motifs because of the nature of the weaving techniques have the tendency to become geometrical in design (Norwani, 2002).

This study was conducted to achieve the following objectives;
1.   To explore the mathematical thinking of the Malay *songket* weavers.
2.   To identify the mathematics concepts used by the *songket* weavers.

2.   Methodology

This is a qualitative research and data was collected by interviewing and observing three weavers from the *songket* weaving industry of the Yayasan Tuanku Nur Zahirah (YTNZ) in Terengganu. YTNZ, founded in 2007, is a foundation under the royal patronage of Her Majesty the Queen of Malaysia, Seri Paduka Baginda Raja Permaisuri Agong Tuanku Nur Zahirah. YTNZ plays a central role in preserving, enhancing and stimulating the *songket*-weaving industry. Forty weavers and two designers are placed in YTNZ Terengganu. The weavers are taught the whole process of *songket* weaving, from the dyeing of the threads to weaving the final product.

Background of the three weavers involved in this study:
Two of the weavers obtained their Diploma in Weaving from Institut Kraf Negara IKN (National Craft Institute) in Rawang before joining YTNZ and they have been in YTNZ for 2-3 years. Another weaver had learned the basic of songket weaving from her mother, a traditional *songket* weaver, before joining YTNZ and has been in YTNZ for about 2 years.

The interviews and observations on the weaving process were video-taped (Figure 4). The data from the video tapes was transcribed and was classed into four mathematical concepts. The findings were then drawn.
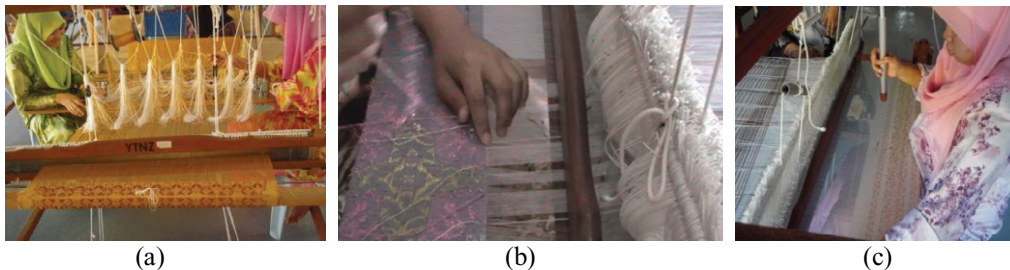

(a)   (b)   (c)

Figure 4: Songket weaving in YTNZ Terengganu

3.   Findings

The *songket* weaving process can be divided into the following steps: designing, dyeing, winding (*menerai*), making a warp (*menganing*), rolling (*menggulung*), sleying the reed (*menyapuk*), setting up the loom, setting up a double heddle (*mengarat*), picking up the pattern (*menyongket*), saving the pattern (*mengikat butang*) and weaving (*menenun*). For the purpose of this paper, the findings are only based on the interviews and the observations done on the weavers in the designing, the *menyongket* and the weaving process. Discussed below are at least four of the mathematical concepts identified by the researchers on the mathematical thinking embedded in the mind of the weavers based on the interpretation of the researchers.

3.1   Transformation

a. Transformation from real object to *songket* motif

According to the weavers, the idea for the motifs comes from their observation on the flowers, leaves, fruits and animals in their environment.

(For all the excerpts given below P represents the interviewer, S1 represents weaver 1, S2 represents weaver 2, S3 represents weaver 3)

From one of the excerpts:
P :   Masa buat corak tu, … berpandukan apa corak yang dibuat tu?
S2:   Berpandukan… dia tengok atas tema kita. ....contohnya kita ambil bunga, satu benda tu… kononnya pisang, kita olah-olah dia tu, jadi bentuk tu.
P :   Jadi yang idea-idea datang tu, daripada mana tu? Adakah khayalan kita je ke?
S2:   Tak… tengok lah… macam kalau kita rasa nak buat pisang lah… pisang tu kita buka dia punya kulit, hirisan dia tu.
P :   Jadi kita tengok pada benda yang ada?
S2:   Ya… kalau benda yang tak de ni, macam dia jadi macam keras. Keras macam tak wujud.
P :   Keras tu maksud macam mana?
S2:   Keras ni … macam benda ni hidup, dia nampak lembut.

For example in designing the *bunga tampuk buah kesemak* (corolla of persimmon fruit) motif (Figure 5) and the *pucuk rebung* (bamboo shoot) motif (Figure 6) (Abdul Shukor,H., et al., 2009), initially they have to analyze and study the attributes of each object, sketch it and then transform the sketch to the graph paper. The weavers then interpret the design on the graph paper using squares, where one square or a dot on the graph paper represents five ends up and one end down (*tekat 5*) or three ends up and one end down (*tekat 3*).
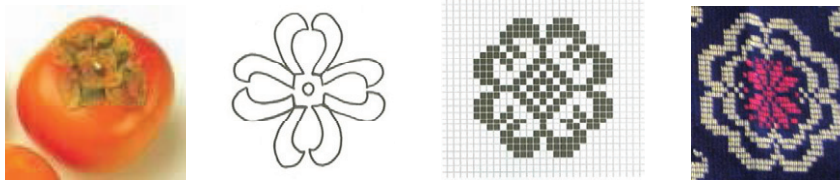

Figure 5: Transforming the corolla of the persimmon fruit to the *bunga tampuk buah kesemak* motif
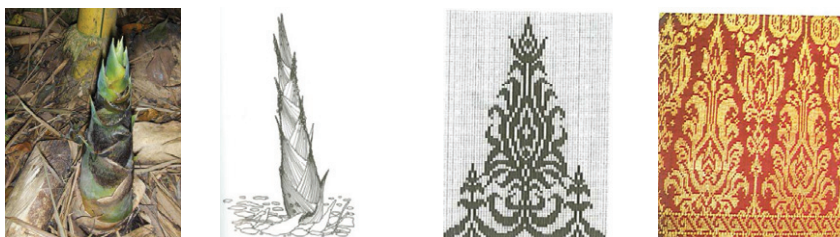

Figure 6: Transforming the bamboo shoot to the *pucuk rebung* motif

b.   Geometrical concepts

Geometrical concepts are obviously seen to be embedded in the weavers' everyday thinking of their weaving process. It is also seen that as a result of the nature of the weaving technique, the *songket* motifs have the tendency to become geometrical in design (Figure 7).
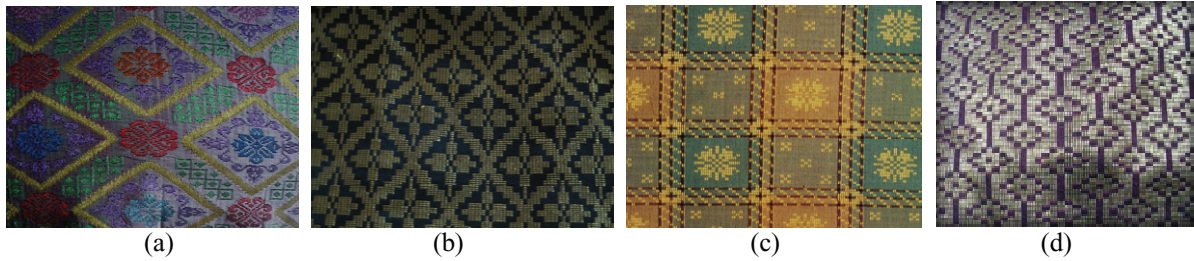
| (a) | (b) | (c) | (d) |

Figure 7: Geometrical shapes songket patterns

From one of the excerpts:

S1: ... macam kita buat petak loseng beragi, loseng beragi tu kita kena kira, kira macam mana jatuh dia, apa semua tu kita kena kira juga.

P : … katakan beragi empatsegi tu, masa kita buat tu jadi empatsegi?

S1: Empatsegi tu mungkin sebab faktor lain juga, sebab… loseng ni macam ni (menunjukkan kedudukan loseng yang menegak), yang dimasukkan itu pakan, loseng ni dah memang sedia ada ragi, lepas tu bila kita masuk pakan, otomatik dia akan jadi empatsegi. Empatsegi ni dulu famous corak Teluk Berantai.

P : Teluk Berantai?

S1: Teluk Berantai… maknanya corak tu memang famous, corak penuh, tapi ia berhubung antara satu sana lain.

P : Selain daripada empatsegi tu, apa lagi bentuk-bentuk matematik yang anda nampak dalam tenunan selama ini? Yang design matematik ada tak? Bentuk geometri?

S1: Geometri? Maknanya designlah? Design… ada jugalah. Kalau sekarang ni, kita buat songket kontemporari, design kita sekarang ni baru datang balik design bunga, dulu memang songket design bulat, petak, tigasegi, semua…

c.   Mathematical transformation

From the weavers' point of view, most of the patterns in *songket* are transversely symmetric, that is, half of the pattern unit is followed by its mirror image (Figure 8). It was found that, the weavers in general do apply the mathematical concept of symmetry, mid-point, repetition and reflection in their weaving process. For example, in weaving the *bunga tampuk buah kesemak* motif, they have to determine the middle point of the pattern, pick half of the pattern (*menyongket/mencolek bunga*) and save the pattern (*mengikat butang*) until half of the pattern are completed. When half of the pattern unit has been woven, its mirror image can be woven by repeating the saved pattern.

Figure 8: A weaver explaining the application of transverse symmetry in the weaving technique

From one of the excerpts:

P : Maknanya you boleh terbalikkan? So, guna macam simetri jugalah.

S1: Ha… simetri, maknanya pembalikan tu.

P : Tapi yang ni tak kan? (menunjukkan ke satu motif songket)

S1: Yang ni tak.

P : Yang pembalikan tu yang macam mana?

S1: Pembalikan tu macam dia bagi separuh . Ha… yang ni design ni … Dia akan bagi separuh je… maknanya kita akan menyongket dari sini ke sini (kiri ke kanan). Yang ni pun boleh juga, dari sini ke sini (atas ke bawah). Kita tengok dari sini pun boleh, dari sini pun boleh (menunjuk ke motif di atas kertas graf)

d.   Scaling

According to the weavers, the warp thread count will determine the size of the motif. *Tekat 3* will produce a smaller motif compared to *tekat 5*. This shows that the mathematical concept of scaling is applied.

From one of the excerpts:
P : Bila kita nak panjang, nak lebar, nak besarkan bunga kat sini (menunjukkan kain yang sedang ditenun)… masa tu anda tahu tak, masa buat tu, dia punya kaitan.
S3: Kalau di sini ada dua, tekat 3 se, tekat 5 se, kalau guna tekat 3 dia akan kecil, kalau tekat 5, design dia akan besar.
P : Kalau yang ini (menunjukkan kain yang ditenun)?
S3: Ini tekat 5. Kalau macam kalau kuda tu besar tu (yang sedang ditenun), kalau tekat 3 saiz kuda tu akan lebih kecil, halus..

3.2   Measurement and estimation

According to the weavers, when they are given the width and the length of each cloth to be weaved*,* they have to produce the desired pattern based on the warp thread counts (tekat 3 or tekat 5). Then they have to do the calculation on the number of *benang loseng (*warp threads) needed for each motif, then determine and measure the placement ('body', 'head', 'foot') of the design and distance between each motif (Figure 9). One of the weavers explained that in determining the width and the length of the cloth to be weaved they also need to take into account the shrinkage factor of the thread. They normally estimate that the final product will shrink one to two inches and have to the adjustment accordingly.

Figure 9: A weaver explaining the measurement and estimation in weaving

From one of the excerpts:
P : Sepanjang anda menenun, 5 tahunkan? Anda nampak tak ada unsur matematik dalam tenunan, dari segi design atau masa peoses buat tu?
S1: Ha… ada juga. Maksudnya masa kita nak apply design tu dari sini (menunjukkan design di atas kertas graf di atas alat menenun) ke atas ini (kain yang ditenun). Kita perlu kira setiap benang ni, maknanya tekat ni, kita kena kira juga, semua ni… satu lagi masa proses, ada juga ukuran dia, sentimeter dia sama ke, sebab kita nak menggulung kena lebihkan seinci, dia akan mengecut lagi seinci, ha… semua tu kita kena kiralah…
P : Perlu anggaran?
S1: Ha… anggaran dia tu… maknanya, kita dah tahu… macam proses menganing, tarik benang, semua tu, dia kena kira juga, macam kita nak sesuaikan dalam ni (alat menenun), berapa kali tarik, ha… berapa kali benang, maknanya kita kena darab… kali-kali, lagi… macam kita buat petak loseng beragi, loseng beragi tu kita kena kira juga, kira macam mana jatuh dia, apa semua tu kita kena kira juga.

It seems that the weaver did not see much of mathematics applied in their work of weaving though we researchers identified a lot of mathematical ideas from their thinking.

3.3   Accuracy

The weavers stressed that it is very important to accurately count the warp threads according to the pattern on the graph paper and to accurately measure the distance and placement of each motif or design in order to be free from mistakes. They will have to redo everything if a mistake is made.

From one of the excerpts:
S2: Contohnya kalau kita tertinggal se (menunjukkan lain yang sedang ditenun) … jadi rugilah di situ, jadi berlubanglah di situ, kalau tinggal satu.
P : Dari segi design cacatlah.
S2: Ha, cacatlah.

P :   Ha… jadi kena tepatlah?
S2: Ha, kena tepatlah, kalau satu je tinggal, kurang ke, lari lah.
P :   Lari? Kalau lari macam mana nak buat pulak?
S2: Kena buka balik lah dan menyongket dan menenun semula.

3.4   Equality

A good woven *songket* is determined on the neatness of the weaving and the evenly tensioned gold or metallic thread. According to the weavers, in the process of weaving, the weft thread is inserted between the shed across the warp using a shuttle (*torak*). The cloth is then hit by sliding the beater/reed (*sikat/jentera*) at a right angle (90°). The use of equal alternate foot pressure on each treadle and equal hitting force on the beater will determine the quality of the finish product (Figure 10).
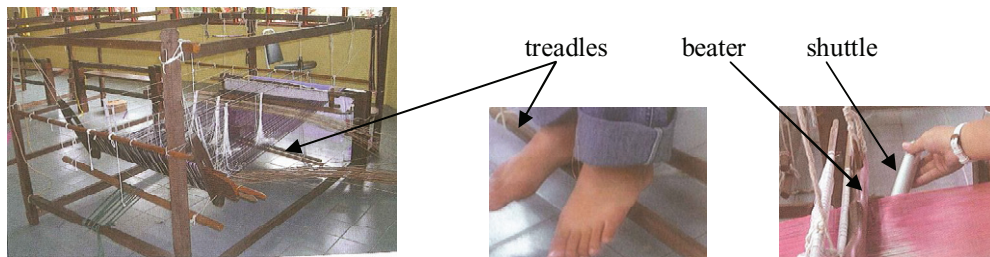

Figure 10: *Kek tenun* (a Malay handloom)

From one of the excerpts:
P :   ...... macam tarik benang?
S2: Ha, sama juga. Kalau karat (menunjukkan bahagian pada alat tenun) pun sama juga. Kalau salah... tinggi rendah, tinggi rendah biasa dah, kalau tertinggal benang ke, berlubang lah. Ataupun dia rasa timbul ke, kendur ke.

4.   Conclusion

Everything has to be accurate, measured, counted and balanced in order to actualize a beautiful *songket*. However, in some part of the process of weaving estimation is needed. From the mathematical thinking of the weavers, these are some of the mathematical concepts that we have identified. At times they have to use their intuition and experience in doing estimations in transforming a natural figure to a *songket* motif that resembles it. As was found, the concept of transformation plays a great role in the process of *songket* weaving. It seems that *songket* weavers are good at visualizing, sharp at remembering and unconsciously they are good at applying mathematics in their work.

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