Mutual Interrogation: A Methodological Process in Ethnomathematical Research

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Abstract

This paper describes an adaptation of a methodology called mutual interrogation to an ethnomathematical study on Malay weaving. Mutual interrogation is the process of implementing a critical dialogue between two knowledge systems; mathematical knowledge and cultural knowledge. It is proposed as a way of resolving several common issues in investigations of mathematical knowledge in cultural practice. Using this approach, a three-phase dialogue between Malay food cover (tudung saji) weavers and mathematicians was implemented. The interactions between the conventions of the weavers and the conceptions of the mathematicians have uncovered several interesting perspectives that address critiques of ethnomathematical research.

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1. Introduction

Ethnomathematics can be envisaged as the bridge that connects mathematics and the ideas and practices of other cultures (Barton, 1996). Ethnomathematicians such as Zaslavsky (1979), Ascher and Ascher (1986), Gerdes (1999; 2005), and many others have investigated various forms of cultural knowledge and activities to look for features that embed mathematical and other scientific thinking. These investigations received some criticisms. For instance, Vithal and Skovsmose (1997) question whether the process of interpreting a cultural practice via mathematical concepts and models to determine the underlying thinking abstractions, will lead to the invention of new mathematical structures that reorganise the reality of the practice. The authors are mainly concerned about the implications and consequences of these investigations on the cultural practitioners; even though their activities are interpreted as embedding mathematics, the practitioners’ views and opinions are not consulted nor considered. Vithal and Skovsmose also point out the lack of ethnomathematical studies that focus on the relation between culture and power. This is despite the fact that the notion of ethnomathematics revolves around culture, and that culture is a social and political construct. Their view echo those of Millroy’s (1992), who provide compelling evidence of the occurrence of power relations among the group of South African carpenters in her study.

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Rowlands and Carson (2000) on the other hand, argue that many cultural practices that can be described mathematically are not necessarily mathematical. Therefore, they question the possibility of abstracting the ‘relevant’ mathematical ideas, and whether the abstraction is pertinent to the actual mathematics of that culture. This perception was later changed, and the authors now admit the prospect of achieving “very high level of (mathematical) abstraction, complexity and eloquence” from the practice (Rowlands & Carson, 2002, p. 92).

As a way of resolving several methodological issues in ethnomathematics, Alangui (2010) proposes an approach called mutual interrogation. This approach is deemed most appropriate for investigations involving the search for mathematical knowledge in cultural practices that are still in existence. It embraces the idea that culture is always changing and in the making, thus acknowledging the interrelations and interactions that take place between and among members of different cultural groups. However, the efficacy of this approach has never been tested any further than in the study that he conducted. To analyse its reliability, it is imperative that mutual interrogation is assessed in other situations and by other researchers before it can be accepted as a valid proposition in ethnomathematical research.

This paper describes an adaptation of mutual interrogation to a study on the cultural practice of food cover, or *tudung saji* weaving among the Malay weavers in Malaysia. The main objective of this study was to document and analyse an attempt to facilitate the realisation of mutual interrogation as a methodological process in ethnomathematical research. In other words, the focus of investigation was not exclusively on the cultural knowledge; rather, the weaving practice was used as the context to explore the efficacy of implementing mutual interrogation.

2. **Mutual Interrogation, as Proposed by Alangui**

Mutual interrogation is defined as “the process of setting up two systems of knowledge in parallel to each other in order to illuminate their similarities and differences, and explore the potential of enhancing and transforming each other” (Alangui, 2010, p. 86). The systems of knowledge refer to the cultural knowledge and conventional, mathematical knowledge. The emphasis is on mathematics, because ethnomathematics is about finding or uncovering different ways of knowing that are regarded as constituting mathematical elements. The interrogation that occurs between the two knowledge systems is carried out through the process of critical dialogue that takes place between the cultural practitioners and the mathematicians through the researcher. Alangui maintains that the interactions that occur between Western mathematical knowledge and non-Western knowledge systems with diverse concepts and ways of thinking would eventually lead to a broadening or transformation in conventional mathematical ideas. Furthermore, the transformation might lead to the invention of new mathematical structures, as well as contemporary development of the cultural practice.

Dickenson-Jones (2008) criticised the definition by arguing that if two knowledge systems were set up ‘in parallel’ to each other, then they would never intersect, and hence, it would be impossible for one knowledge system to have any influence on the other. This opinion reveals a misunderstanding of Alangui’s true intention. In one sense, the words ‘in parallel’ in the definition imply the notion of equality. Thus, the two systems of knowledge; cultural knowledge and conventional mathematics, are considered to be equally important in the research process, provided with equal opportunity to interrogate each other, and are given equal value in the final report. In another sense, the two systems are considered parallel in their respective contexts. Therefore, parallels refer to the similarities and differences that are drawn between certain aspects of mathematics and the cultural practice, to show the appropriateness of the latter to interrogate conventional mathematical concepts and beliefs. This is because any transformation of mathematical ideas might occur only when the systems are interacting and interrogating each other equally and critically.

Unlike many other writers in the field, Alangui deliberately avoided using the term ‘mathematics’ or ‘mathematical’ when referring to the cultural knowledge being investigated. His avoidance stemmed from the fact that he did not want to restrict his perspectives on what mathematics is all about, which might have caused him to focus only on aspects of the cultural practice or knowledge that resemble conventional mathematics. Instead, he adopted Barton’s (1999a) notion of QRS system, which is defined as a system of meanings that occur when a group of people attempt to manage quantities, form relationships and represent space within their own surroundings (Barton, 1999a, 1999b).
In other words, the QRS system encompasses other forms of knowledge or ways of thinking that might not initially be recognised as mathematical. Therefore, mutual interrogation allows the structures of cultural practice to be related to formal mathematics without using any external criteria. This approach of broadening the conception of mathematics counters the above view assumed by Rowlands and Carson (2000), where they focus only on the conventional, Western mathematical concepts when questioning the embeddedness of mathematical ideas in cultural practice.

The main reason for the development of this methodology is to avoid the unintentional perpetration of ‘ideological colonialism’ and ‘knowledge decontextualisation’ in ethnomathematical research (Alangui, 2010). Ideological colonialism or colonisation is defined as “the imposition of concepts and structures of mathematics onto the knowledge embedded in cultural practice”, whereas knowledge decontextualisation is “the taking of knowledge and practice out of their cultural context in order to highlight their ‘inherent’ mathematical value” (p. 11). Alangui believes that to avoid these ‘dual dangers’, it is essential to have critique and dialogue that involve constant interrogation and challenges of assumptions, perspectives and methods. Since mutual interrogation acknowledges the standpoint and expertise of both knowledge systems, the dialogue becomes a platform for the cultural practitioners to voice their views and opinions. This is one instance where mutual interrogation addresses the concern raised by Vithal and Skovsmose (1997), who argue that the implications and consequences for the people whose activities are interpreted are unknown because their views and opinions are not heard.

The researcher, who is also an ethnomathematician, plays a crucial role in this approach. Apart from facilitating the dialogue between the practitioners, the researcher engages in critical reflections, examines his or her assumptions and beliefs about mathematics, and experiences perceptual shifts about mathematics. Thus, mutual interrogation is internal to the researcher. The series of self-questioning, and the dialogue that goes on between him or her (as a representative of the cultural practitioners) and the mathematicians, allow the researcher to interrogate his or her own conceptions about mathematics. External interrogation occurs when the researcher re-presents the views from one knowledge system to be interrogated by the other, and communicates the outcome of the dialogue and his or her perceptual experiences to the larger mathematical communities.

3. Mutual Interrogation, as Conducted in the Study of Tudung Saji Weaving

This qualitative study was conducted with the aim of testing the efficacy of mutual interrogation and facilitating its employment as a methodology in ethnomathematical research. Therefore, mutual interrogation was implemented at a deeper level in this study, sustained in three phases of fieldwork over a period of almost two years. This was to ensure that sufficient data could be collected to warrant the findings reliable. With regard to the dialogue, the prolonged period of communication was to ensure that each party would receive ample opportunities to interrogate the other, and that matters of interest would be adequately and satisfactorily discussed through repeated interactions. Fieldwork with the weavers was geared towards forming an understanding of the weaving processes, the relevant concepts involved, and the limitations and possibilities that are associated with tudung saji weaving.

In the context of this study, the dialogue was based on the interactions between the weaving conventions of Malay tudung saji weavers and the mathematical conceptions of mathematicians. Apart from being the ethnomathematical researcher, I also played the role of mediator of the dialogue. This role provided me with the means to reflect on the way I conducted the investigation, and helped me to examine my assumptions about mathematics, and to perceive how mathematical ideas are embedded in weaving. The series of reflections and questioning of assumptions and beliefs that I engaged in led to perceptual shifts about mathematics, and resulted in the development of a weaving template.

Dialogue participants consisted of four weavers and six mathematicians; the former group was selected based on their experience, whereas the latter on their interest and expertise in mathematical areas that are deemed suitable to interrogate weaving. Data was collected using ethnographic methods of participant-observation, unstructured and semi-structured interviews, audio and video recordings, and fieldnotes. Data analysis was guided by the research objectives, where the primary focus of analysis was on identifying recurring patterns or common themes in the interactions.
4. The Malay Tudung Saji

Although they used to be objects that were commonly found all over Malaysia and the surrounding region (Gibson-Hill, 1951), the Malay tudung saji are nowadays made in only a few states of the country due to a dwindling number of weavers. The scope of this study was confined to the tudung saji that are still being produced in the states of Melaka and Terengganu. These conical objects are woven using a specific technique called triaxial or hexagonal weave, where the strands are plaited in three directions. The weaver begins her work by building a cone-shaped latticework of pentagonal and hexagonal openings, which functions as a framework for the tudung saji. Multicoloured strands are then woven through the openings to create patterns. The weavers generally talk about pattern formation in relation to the five segments of the tudung saji, as highlighted in the fifth photo of Figure 1.

Figure 1: A framework (far left) and several common tudung saji patterns

I started the dialogue by showing samples of the woven objects to the mathematicians to record their first impressions. The following are discussions of the findings from the dialogue, with regard to the weaving technique, framework construction and pattern formation.

4.1 Mathematical Observations

The mathematicians used words like ‘tessellated parallelograms’ and ‘repeating hexagons’ to describe what they saw, noting that some of the patterns appear neat and simple whereas others seem more complex and intricate. On the whole, the mathematicians were mostly interested in the formation of the patterns. They perceived the symmetry in the colourfully tessellated patterns, and the way the different coloured strands are repeated in each of the five segments in order to form the desired patterns or designs. They observed that many of the patterns, which are forced by the choice of colours, have five-fold symmetry at the top and six-fold symmetry everywhere else due to the way the strands are woven through the framework openings.

4.2 Discontinuity in Certain Patterns

In Phase 1 of fieldwork, the mathematicians were curious about the discontinuity observed on some of the patterns, such as the third pattern displayed in Figure 1. Here, the parallel rows of ‘sailboats’ seen on half of the surface are disrupted near the top by a discontinuity line that splits the motifs in two directions.

When I relayed this matter to the weavers in Phase 2, they explained that the discontinuity is a natural occurrence that results when there are two colours at the peak. According to them, it is the interaction between the insertions at the two-colour peak and the insertions on the body of the framework that causes the discontinuities seen on some of the patterns. In certain cases, the distortions can be corrected by covering them with extra strips, but in other cases, they are too extensive to be corrected and are thus left alone.

4.3 Reconstruction of Framework

When I fed back to the mathematicians that the weaving of the framework must be started with five strands in order to form a curvature at the pentagon and attain the conical shape, the mathematicians mulled this over and wondered whether it would be possible to build the framework with another number of strands. They accepted the weavers’ claim that the structure would lie flat if the weaving was started with six strands, but they were curious and wanted to know what would happen if the framework was begun with three, four or seven strands.
Toward the end of Phase 1, I built a conical-shaped, triaxially-woven latticework that was started with four strands, based on the structural construction of old Chinese hats (Gibson-Hill, 1952). I showed this structure to the weavers in Phase 2 and they were invited to reconstruct it and figure out possible ways of filling up the openings. Since they had always believed that the conical shape could only be obtained with a starting point of five strands, all of the weavers were quite surprised to see their weaving convention challenged. Even though they eventually succeeded in forming a peak of four strands, the weavers did not like the shape, which when compared to the regular five-strand peak cover, is sharper at the apex and narrower around the edge. They unanimously decided that the new structure was unsuitable to be used as a *tudung saji*.

Two of the weavers later claimed that it is possible to make a three-strand-peak *tudung saji*. However, the triaxial weave occurs only at the apex, while square weaves, where the strands are interlaced perpendicularly to each other, covers the entire body. The square weave, which is often associated with mat weaving, does not permit any openings, requires no insertions, and does not allow the creation of the typical *tudung saji* patterns. The three-strand-peak *tudung saji* is unpopular with the weavers because it is much more difficult to make, time-consuming and costly. Furthermore, only weavers who are skilled in the creation of the mat weaving patterns can produce a cover of this type.

In Phase 2, some of the weavers predicted that they would require seven strands to fill up the tip of a seven-strand-peak, conical framework. However, they did not anticipate a sharp peak because the opening was assumed to be larger than usual. When I related the weavers’ opinion to the mathematicians, one of them asserted that it should be possible to build a seven-strand peak structure. Basing his argument on concepts in hyperbolic geometry, he predicted that the formation would be saddle-shaped, instead of conical. He added that although the weavers might find the saddle shape of no use to them, it would still be an interesting finding from a mathematical point of view. At the beginning of Phase 3, the weavers were invited to separately weave a framework that was started with seven strands. The outcome was exactly as that predicted by the mathematician – the object lost its conical shape altogether and instead was transformed into something that was noticeably saddle-shaped in appearance. Furthermore, the curviness became more pronounced after the proper insertions were made to close the openings. Nevertheless, all of the weavers were quite indifferent to this object because it was considered not relevant to their weaving practice. The mathematicians on the other hand, showed significant interest in the transformed shape and the underlying mathematical properties that caused the transformation.

Gerdes (1994) suggests that hidden mathematical ideas can be uncovered through a reconstruction of past knowledge. In order to understand the reasons behind the form of the product, it is necessary to learn the production techniques and vary the form at each stage of the process. This method is claimed to be helpful in observing the practicality of the product and the possibility of the form being the optimal or only solution of a production problem. This view is relevant to the issue of *tudung saji* construction. Even though the conical shape could still be obtained by using three or four strands as the starting point, it appears that a starting point of five strands is the most favourable in ensuring the right proportion in the shape and size of the covers.

![Figure 2: Three-strand-peak (left), four-strand-peak (centre) and seven-strand-starting point (right) structures](image)

4.4 Extension to Weaving

The experiments that were conducted in Phase 2 (where the weavers built frameworks that were started with four strands) led to an extension of constructive concepts in one of the weavers. She had successfully created two versions of *tudung saji* that consisted of two and three peaks, respectively. When I displayed samples of these covers to the other weavers, all of them liked the double-peak version, which was decidedly wider around the edge when compared...
to the regular single-peak, and therefore would be able to cover more dishes of food. Furthermore, a string could be attached from one peak to the other, which acts as a handle to lift the cover or hang it on the wall when it is not in use. On the other hand, the triple-peak cover did not generate much interest among the weavers due to its steepness.

![Figure 3: Double-peak (left) and triple-peak (right) tudung saji](image)

A positive implication of this innovation is the potentiality of the double-peak tudung saji being sold in the market. The same weaver had previously had some success in selling the ‘high and narrow’ tudung saji that she built by interweaving only four strands at the starting point (i.e. the four-strand peak cover). Despite the negative views that were adopted by the other weavers with regard to its odd-looking shape, she had found it an interesting invention and wanted to test its saleability. According to her, one of the buyers purchased the tudung saji because of its height, which was considered useful for covering tall objects like tea sets. It was in fact the success of her sales that prompted her to think beyond her normal weaving scope, which subsequently led to the conception of the idea behind the creation of the double-peak and triple-peak versions described above.

4.5 Weaving Template

At the end of Phase 1, I developed a computer-generated weaving template and created several fictitious patterns. In Phase 2, I sought the weavers’ opinions on the feasibility of making these patterns on the tudung saji. The general impression that I gained from this exercise was that all of the fictitious patterns could be created; it was just a matter of knowing whether they could occur naturally, or if there were parts that would require some manipulation. Figure 4 displays two samples of these fictitious patterns.

![Figure 4: Fictitious patterns](image)

One weaver who was very excited when first told about the weaving template, showed some disappointment when she finally saw it. She had thought she could use it to create new patterns, but upon seeing the template, she realised that it was only good for producing patterns on a flat surface, and would not work for creating patterns on the three-dimensional framework. This is because the weaving structure on the template does not follow the weavers’ convention, where three out of five segments are covered at each stage of weaving, and that patterns are fully formed after the fifth stage. The weaver suggested that I modified the template to include all five segments, instead of showing just one.

I took the weaver’s comment into account and attempted to alter the weaving template to suit the weaving convention. However, the template was constructed in such a way that made it impossible for me to connect all five segments and imitate the proper weaving technique. I sought the advice of a mathematician, who suggested that I
used the LaTeX PSTricks package to simultaneously display all five segments. The process of creating a common pattern revealed how the structure would look if the peak consisted of seven strands (Figure 5, left). The wave-like appearance of the seven-strand peak is consistent with the saddle-shape formation that was predicted by the mathematician earlier.

Figure 5: Comparison between seven-strand-peak (left) and five-strand-peak (right) structures

With regard to the perceived limitation of the weaving template, one mathematician commented that it is not necessary to create a template that exactly emulates the weaving convention of the weavers in order to show how the patterns are formed. His argument revolved around the fact that mathematicians are not interested in learning the know-how of tudung saji making, thus it is sufficient to display only a single segment to represent each pattern. However, he had overlooked a crucial element in the process of tudung saji weaving, namely the framework construction. By pointing out why it would be almost impossible to determine the viability of pattern creation based on a single segment, the weaver was in fact highlighting the importance of the framework in her practice. Her depth of knowledge of the practice had contributed in highlighting an aspect of weaving that would otherwise have gone unnoticed.

5. Conclusion

From the above findings, it appears that the interactions between the weavers and the mathematicians had succeeded in uncovering several perspectives that concerned both parties. This is evidenced by the innovative ideas developed by one of the weavers since participating in the dialogue with the mathematicians, as shown from her creation of double-peak and triple-peak tudung saji. To a certain extent, the dialogue had helped in enhancing the constructive concepts and changing the weaving perspectives of the weavers. The mathematicians on the other hand, had gained some insights in Malay tudung saji weaving, a cultural practice that was previously unknown to them. They were quite fascinated not only by the aesthetic values of the objects, but also by the mathematical ideas that are embedded within the practice.

On the whole, the weavers and the mathematicians were both highly engaged in the dialogue, especially in the first two phases. Nevertheless, the weavers did not quite interrogate the mathematicians as much as they were being interrogated. Instead, they preferred to simply accommodate the wishes of the mathematicians by following their suggestions and answering the queries that were posed to them. This was especially apparent in the last two phases, when the investigation was focussed more on uncovering the mathematical ideas behind the framework construction. A possible explanation for this imbalance could be attributed to the difference in perspectives, an aspect that is normally dependent on the individuals’ background and interest. The tudung saji evoked mathematical curiosity in the mathematicians, so they posed questions and made suggestions to satisfy their curiosity. On the other hand, the weavers in general did not have much of a mathematical background to begin with, and therefore did not develop many insights into the abstract world of mathematics. As admitted by several of the weavers, mathematics is a subject area that is beyond their understanding. As a result, they did not know what questions should be posed to the mathematicians with regard to their weaving practice. Nevertheless, even though the weavers might not normally be looking at the things around them with a mathematical eye, they could see some form of mathematical elements in their weaving practice, citing the relationship between the techniques in pattern formation and the emerging patterns as an example.

Another possible explanation for the inequality in the interrogation is due to the existence of power relations between the practitioners. The weavers perceived the mathematicians as highly knowledgeable people and might
have felt quite intimidated when they were brought together through the dialogue. The mathematicians on the other hand, were confident in their understanding of their knowledge system and therefore felt comfortable enough to interrogate the weavers. In this context, power relations existed even though the practitioners did not meet face-to-face. This is consistent with Vithal and Skovsmose’s argument, who assert that cultural practice “is not only the result of interactions with the natural and social environment but also subjected to interactions with the power relations both among and within cultural groups” (Vithal & Skovsmose, 1997, p. 140).

So, is mutual interrogation an effective methodology in ethnomathematics? The answer to this question lies in how its efficacy is perceived. Practitioners who take part in the dialogue can rest assured that their voices would be heard. They will also get equal (and ample) opportunity to interrogate each other, to exchange ideas between members of the same group, and to enhance their understanding of the practice of the other group. There is evidence that the dialogue could contribute towards extending the conceptions of the cultural practitioners about their own practice, as shown in the study, where the weavers’ attention were drawn to the ways that mathematical theories could be used to enhance their weaving practice. In this sense, the perceptual shifts and the alternative conceptions were experienced both by the researcher as well as the practitioners.

The ethnomathematician mediator plays a major role in this approach. It is his or her reflections on the things that has been said and done, and the perceptual shifts that he or she undergoes during the investigation, that keep the dialogue going. Care must be taken here, because whatever that the researcher chooses to highlight to the other party would determine to a certain extent the way the dialogue goes. During the interactions and the communication of the outcome, the researcher must be open to ideas and opinions, and willing to allow his or her mathematical conceptions to be challenged. Then only a transformation in mathematical ideas could occur.

References