BRIGHT LIGHTS AND QUESTIONS: USING MUTUAL INTERROGATION

AISHIKIN ADAM, WILLY ALANGUI, BILL BARTON

Bound to a hard chair in a darkened room. The chilling smell of fear. Click, and a spotlight blazes into your eyes. The interrogation is about to begin.

But this interrogation will be different. This is mutual interrogation. Mutual interrogation? Surely that is oxymoronic? We do not think so. Mutual interrogation is a methodology for ethnomathematical investigation. We wish to be able to ask each other penetrating questions about mathematical systems of knowledge.

Think of a culturally specific practice such as stonewalling, basket weaving, or building a house in urban America. These are systems of knowledge in their own right, but we can recognise a mathematical character within them. The mathematical aspects may not reflect mathematics as we know it – indeed, the cultural practice may embody alternative conceptions of quantity, relationships, or space. We are searching, therefore, for a methodology and a technique that will allow us to put mathematics and stonewalling into parallel. We wish to illuminate differences in a way that can potentially enhance either (or both) systems. Alangui proposes mutual interrogation as the way to retain cultural integrity. [1]

We now have three substantial examples of mutual interrogation in action. What can we say about how it worked out, and its potential for future ethnomathematical study? Does the usually dominant, near-universal system of mathematics terrorise any context-specific practice? Can the prisoner and the interrogator exchange roles? Will mathematics give up some of its secrets in the process?

Before we try to answer our own questions, we specify what we mean by mutual interrogation, and describe the three instances. Allow us to share Willy Alangui's personal journey as a backdrop to how the concept came about.

The road to mutual interrogation – Willy's story

The mid-1980s were a defining period in Philippine history. Unprecedented social, political and economic crises, outrage over the assassination of a prominent politician, and disgust over a presidential election, all contributed to a people's movement that led to the ousting of Ferdinand Marcos, ending two decades of dictatorial rule. I was a freshman at the University of the Philippines in Baguio City at the time of the assassination. The killing opened my eyes to the harsh realities of Philippine life: the widening gap between the rich and the poor; injustices committed on ordinary people; the militarisation of the countryside; and violations of human rights that included summary executions, abductions, torture, and interrogation of political activists.

I became a part of a social movement that included farmers, workers, urban poor, students, teachers, church workers, women, and indigenous peoples. As a student, then later as a mathematics teacher, I gravitated towards issues about education. We called for an overhaul of the educational system. We pushed for a relevant and critical education, and a reorientation of the school curriculum to Philippine social realities.

Whilst other student activists had serious questions about the subjects that they were majoring in (for example, neoliberal models of development in Economics), I found no conflict between being an activist and being a mathematician. Only when I became a teacher did I seriously question the relevance of *the* mathematics that I was teaching, as well as the meaning of my being a mathematician, to the larger issues of democracy and social justice. The search for meaning and relevance led me to ethnomathematics.

My activism also helped me to understand and celebrate my being an indigenous person. My father belonged to the northern *Kankana-ey* people, one of the more than a dozen ethnolinguistic groups in the Cordillera region, collectively called *Igorot*. He went to the 'lowlands' in his teens, and later married my non-indigenous mother. As a young boy, my being an *Igorot* simply meant having a different culture, one that was at the same time alien to me, having been raised within the dominant culture of the lowlands. My involvement with the Left paved the way for my deeper appreciation of my identity as an *Igorot*, and taught me about the indigenous peoples' struggle. The issues that the indigenous peoples of the Philippines were facing then revolved around the right to self-determination, control over indigenous lands and territories, human rights abuses, discrimination, and commercialisation of indigenous culture. They/we continue to be fighting for these issues, now more complex because of globalisation. Theft of indigenous knowledge has also become a major issue facing the indigenous peoples the world over.

The interactions I had with other indigenous activists, and immersions in indigenous communities, changed me in fundamental ways. Not only did I embrace their issues, I also learned the ways of the *Igorot* (and I am still learning). I sang the songs that spoke of issues important to them/us. In indigenous gatherings, I learned to play the gongs and danced the *Igorot* dance. It was easy to get lost in the rhythm of dance and music, the act of losing oneself has become a metaphor of how I have come to appreciate my indigeneity. Lineage gave me the right to identify myself as an indigenous person. I have *Igorot* blood, but I believe I only became *Igorot* when I understood and embraced the indigenous struggle.

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My history and lived experiences helped shape my consciousness, values and principles. My desire for relevant and critical mathematics education, and my questioning of appropriate mathematical investigations of cultural practices, are a reflection of my being an indigenous activist and mathematician. I needed to learn about culture in an academic way, and this led me to issues of alterity (otherness) (Taussig, 1993) and changing concepts of culture in anthropology (Ray, 2001). If the concept of culture is to be found in reflexive cultural contact, then ethnomathematics might similarly be found in reflexive questioning of systems of knowledge.

The development of mutual interrogation as a methodology in ethnomathematics reflects lessons I learned from working with various indigenous peoples at home and at the UN, and my desire to change the dynamics of the encounter between knowledge systems. [1]

What is mutual interrogation?

Mutual interrogation is the process of setting up two systems of knowledge in parallel to each other in order to illuminate their similarities and differences, and to explore the potential of enhancing and transforming each other. In the context of ethnomathematical research, mutual interrogation is a process facilitated by the ethnomathematician – the researcher.

Larrivee's (2000) description of the stages in becoming a critically reflective teacher (in the sense of Freire, 1973) finds resonance in the way the process of mutual interrogation is developed. For Larrivee, critical reflection involves an examination of current practice (questioning, challenging, and desire for change), followed by struggle and fear (inner conflict, surrender, uncertainty, and chaos), then the occurrence of a perceptual shift (reconciling, personal discovery, and new practice) that then leads to transformation.

The process of mutual interrogation, or critical dialogue, in ethnomathematics is similar. However, the examination of our assumptions and beliefs about mathematics is not a linear process. It is a series of reflections and questions, one that is "plagued by incremental fluctuations of irregular progress, often marked by two steps forward and one step backward" (Larrivee, 2000, p. 304). This back and forth dialogue characterises the whole process, from the time one starts looking, to when something is found, and up to the moment of deciding what can be made of it. Uncertainty is an integral part of the process. For Larrivee (2000, p. 304), "uncertainty is the hallmark for transformation and the emergence of new possibilities." And because of this, shifts in perception about mathematics and alternative conceptions might occur after one goes through struggle and uncertainty, and starts reconciling and discovering new things. Alternative conceptions, perceptual shifts, and the development of new mathematics all contribute to transformation.

Mutual interrogation is an approach in ethnomathematics in which the ethnomathematician:

- sets up a critical dialogue between cultural practice and mathematics;
- draws up parallels between the two practices, using elements in one system to ask questions of the other;
- engages in reflection and questioning of assumptions about mathematics; and
- explores alternative conceptions.

Mutual interrogation is faithful to the notion of culture as shared practice, viewing cultures as continually interacting with each other. It is also consistent with the use of the window metaphor [2] in which actors can gaze in either direction through it. The ethnomathematician endeavours to move from side-to-side of this window.

The role of the ethnomathematician

Ethnomathematicians are thus at the centre of the interrogation process. They initiate the interrogation guided by a critical re-presentation of the cultural practice under investigation. They examine assumptions and beliefs about mathematics, struggle and undergo uncertainty and fear. They experience perceptual shifts about mathematics. In a sense, the interrogation is internal to the ethnomathematician. It is their conception of mathematics and their perception of cultural practice that are brought into parallel.

What happens after this restructuring of experience will largely depend on how the ethnomathematician effectively communicates his or her results to the larger mathematical and cultural community.

The way mutual interrogation was developed reflects a belief held by many ethnomathematicians, and reiterated by Kincheloe and Steinberg (2008), that knowledge embedded in cultural practice can provide "a provocative vantage point from which to view Eurocentric discourses, a starting place for a new conversation about the world and human beings' role in it" (Kincheloe & Steinberg, 2008, p. 152).

Alangui's research on the cultural knowledge embedded in the practice of rice terracing agriculture in the Cordillera region, north of the Philippines, and Adam's study on triaxial weaving in Malaysia are works that challenge our conventional methods of how we generate mathematical knowledge. They resonate with the position forwarded by Kincheloe and Steinberg (2008, pp. 151–152) about indigenous (and cultural) knowledge and its power to reshape Western science. They talk about examining "the relationship between Western science and indigenous ways of knowing in a manner that highlights their differences and complementarities, … concerned with initiating a conversation resulting in a critique of Western science that leads to a reconceptualization of the Western scientific project."

This article provides examples of how mutual interrogation may proceed. It views Alangui's study as initial explorations in the development of the idea, and Adam's work as providing refinement. Then we look back and review Millroy's explorations with carpenters in South Africa from the perspective of mutual interrogation.

Three examples

Modelling water flows

Willy's study in the villages of Agawa and Gueday focused on two aspects of the rice terracing practice, namely stone walling and managing water flows in the rice paddies. His ethnographic work for five months allowed him to build relationships with the practitioners and the community. He engaged in various activities that helped him understand the practices – he assisted in building a stone wall, helped clean up and direct water in the paddies, and joined locals in a half-day trek deep in the forest to visit the water source of a major irrigation system. During his stay, he documented the technical aspects of stone walling and water flow management, how the practitioners talk about them (for example, their use of metaphors), as well as the myths and beliefs surrounding the practices. His assumption was that, as highly-developed cultural practices, stone walling and managing water flows may be used to interrogate mathematics.

Managing the network of water flows on a cluster of rice fields or *papayeo* is a crucial aspect of the rice terracing practice. This network is connected by a series of water outlets (*gusingan*) that allows water to go in and out of a rice paddy (*payeo*). The goal is always that water is made available to each and every paddy in this network of rice terraces. Farmers with paddies located at higher levels in the cluster have to ensure that water is properly directed to the paddies below them.

From a mathematical perspective, managing water flows in a cluster of rice paddies is a complex problem [3], and his dialogues with Geoff, an applied mathematician from the Department of Mathematics at the University of Auckland in New Zealand, allowed him to interrogate his assumptions about the practice. Informed by the ethnographic data, Geoff and Willy engaged in a series of dialogues where they developed several mathematical models that they thought aptly captured the dynamics of the practice. They incorporated in the models what they believed were important variables like area of the paddy, rate of flow of water going into and going out from a paddy, seepage and evaporation. Geoff 'interrogated' Willy about the details of the practice, and Willy 'interrogated' back to make sure that he understood and contributed to the model that they were developing. As the ethnomathematician facilitating the dialogue, Willy represented the voice of the farmers of Agawa and Gueday. Geoff represented the voice of the mathematician.

The variables that Geoff and Willy reflected in the models were those that readily lent themselves to some degree of measurement – they had to be quantifiable. In a later phase, Willy represented the voice of the mathematician and the farmers were the practitioners' voice as they interrogated these models and exposed their insufficiency. The variables Willy had thought were critical for the cultural practice were conceptually different from those of the practitioners. From the perspective of the practitioners, the most critical value was the responsibility of every farmer to share water with everyone. This social responsibility is known to every farmer in the community, and is governed by the belief that *"dagiti papayeo ditoy baba ti mangit-ited ti danum dita ngato"* (the rice paddies that are found at the lower places in the network are the ones providing water to the *papayeo* above). This puzzling statement may be explained by the enduring practice of *og-ogbo* or reciprocal labour cooperation where people share a work load without compensation. The age old irrigation systems in Agawa and Gueday were built through *og-ogbo*. And if it were not for the need to water the rice fields at the lower areas, people would not have voluntarily built the irrigation systems that are now in place. It is in this sense that the *papayeo* below are the ones providing water to those found at higher places in the cluster. In other words, indigenous ways of water management are governed by certain cultural values and ethics, one of which is the notion that no one has the right to monopolise water. In Agawa and Gueday, such an ethic is best captured by *binnanes,* a system of water rotation amongst clusters of rice paddies especially during periods when water is critical.

As the ethnomathematician who studied the practice, Willy became aware that representing the practitioners in the dialogues is not unproblematic. The succeeding dialogues in which he represented the mathematicians allowed him to re-view the models that were developed. Mutual interrogation allowed him to realise that the water flow models did not reflect the most important 'variable' of social responsibility to provide water to everyone, as exemplified in the practice of *binnanes*.

A challenge was thus presented to the mathematicians to find ways to incorporate such variables to make effective models. From their point of view as mathematicians, a good model of water flow depended on its ability to explain the physical dynamics of the practice, which in turn depended on the 'correctness' of the variables that they chose to include in the model. Because of this, one would expect that predictions afforded by their mathematical model would concern aspects of water flow management that are mathematically measurable. On the other hand, the process of mutual interrogation made Willy realise that if mathematicians think as the practitioners, a good 'model' will no longer simply allow them to explain, or even solve, physical problems about water flows, but will also make them understand better how community values and social ethics regulate such a practice.

Malay food covers

The weaving of the Malay food covers, known as *tudung saji* in the Malay language, uses a weaving technique called triaxial or hexagonal weave, where the strands are plaited in three directions. Previously food covers were common in households all over Malaysia (Gibson-Hill, 1951), they are now made in only a few states of the country.

Aishikin's ethnomathematical study involved a deliberate three-cycle dialogue between food cover weavers and mathematicians, with her as mediator. In the first cycle, Aishikin spent two months in the field with four weavers to observe and learn how to weave. Most information was gathered through informal conversations centred on weaving technique, structure, and pattern formation. She learned to construct a cone-shaped latticework consisting of a pentagonal opening at the tip and hexagonal openings elsewhere. This framework develops as coloured strands are woven through the openings in three directions and finally the rounded edge is tightly bound.

Her teachers showed her how to form the various patterns: for example, *Bunga Tanjung* (the name of a star-shaped flower), *Tebeng Layar* (Spread Sails), *Pati Sekawan* (A Flock of Pigeons) and *Kapal Layar* (Sailboat). They had memorised the common patterns and the steps involved in creating them, but also had generated their own patterns.

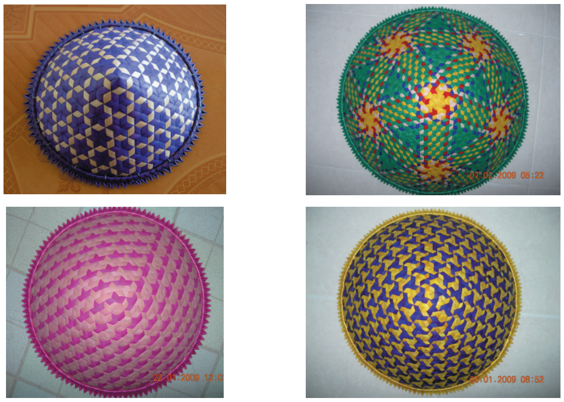

Figure 1. From left to right: Bunga Tanjung, Tebeng Layar, Kapal Layar and Pati Sekawan

Aishikin then met with several mathematicians to document their first impressions of the food covers. Phrases like 'tessellated parallelograms' and 'repeating hexagons' were used to describe what they observed. The mathematicians were mainly interested in the formation of the patterns. They perceived the symmetry and the repetition of the different coloured strands. They were curious about the discontinuity observed in some of the patterns. A mathematician conjectured that the difference could lie in the way the coloured strands intersected at the peak. They were eager to hear the weavers' explanation.

The mathematicians also discussed why the weaving of the framework must be started with five strands, and wanted to know what would happen if the weaving of the framework was begun with three, four or seven strands. Aishikin found an example of Chinese weaving starting with four strands, and constructed a replica to be shown to the weavers in Cycle 2.

As a tool for her mediation, Aishikin developed a weaving computer template to generate triaxially-woven plane patterns. She created several fictitious patterns to be shown to the weavers during the Cycle 2 fieldwork.

In Cycle 2, eight months later, the weavers explained the discontinuities, displaying their knowledge of when one occurs and why. They demonstrated that they knew when it was possible to disguise the discontinuity, how to do it, and why it would not always be possible. When Aishikin showed the weavers the four-strand-peak conical latticework, they were amazed because they had not thought it could be done. When asked to fill the opening at the tip, their first instinct was to employ the familiar procedure but found that it was not possible. However, they solved the problem, and wove the rest of the body. Nevertheless, the peak was too sharp for their taste, and they suggested that the object might be better as a lampshade!

The novel framework made one weaver wonder how the four strands at the peak would affect the discontinuity of the *Kapal Layar* pattern. Upon construction, she discovered that instead of one, there were now two places of discontinuity in the pattern. Since the four pillars of the framework partitioned the cover into four sections, she also wondered whether she could modify the edge to build a pyramid-shaped food cover with a rectangular base. The idea excited her, as the originality would make her food covers stand out more in the market.

Since Cycle 1, two weavers had found out that the structure could also be started with 3 strands but that the subsequent weaving technique follows the rectangular mat weaving style. This modified type was not popular with the weavers because it is difficult to make. Also, more strands are needed in the weaving process, thereby increasing the cost of production. They also look good only on the smaller sizes, as the structure loses its conical shape if the size is enlarged.

Aishikin showed the weavers some fictitious patterns on the computer template. The weavers were divided on whether they were possible to create without pasting on appropriately coloured strands. One kept a copy and a day later showed Aishikin the ones that she had tried, confirming her suspicion that some of the patterns could be woven. She found these patterns interesting and wanted to create them on her covers.

Another weaver, who was very excited when first told about the weaving template, showed some disappointment when she finally saw it. She had thought that the template could be used to help her in creating new patterns, something that she had always wanted to do. However, she realised that the template was only good for producing patterns on a flat surface, and might not work for creating patterns on the three-dimensional framework because the template structure does not follow the weavers' convention, where 3 out of 5 sections of the cover are covered at each stage of weaving. She suggested that the template be modified to represent all 5 sections. This provided Aishikin with new insights into the weaving process and a modification of the template.

The subsequent discussions with the mathematicians were centred mainly on the outcome of the reconstructed framework. The samples of the three- and four-strand peaks resolved their former curiosity.

With regard to the modification of the weaving template, one mathematician commented that it is not necessary to emulate the weaving convention of having five connected sections. His argument revolved around the fact that mathematicians are not interested in learning the know-how of food cover making, it is sufficient to display only a single section to represent each of the patterns. His blindness to the structural nature of the pattern restriction in this context, and dismissal of it as a mere practical impediment to "true" patterns, is an example of dialogue breakdown through preconceived notions.

One weaver had had some success in selling the high and narrow four-strand-peak cover that she built in Cycle 2. Despite the negative views with regard to its odd-looking shape, she had wanted to test its saleability. One of the buyers bought the cover because its height was useful for covering tall objects like tea sets. The success of her sales prompted the weaver to think beyond her normal weaving scope, and led her to create versions of cone-shaped covers that had two and three peaks. The two-peak cover is decidedly wider around the edge when compared to the regular one-peak cover, and received nods of approval from the other weavers. They agreed that it functions better at covering food. However, the three-peak cover did not generate much interest among the weavers because of its narrow width and height. The two-peak cover is now being marketed successfully.

At the beginning of Cycle 3, the weavers were invited to weave a framework starting with seven strands. A mathematician had earlier raised this possibility without going into much detail. He had said that it would be possible since the concepts involved are related to those of hyperbolic geometry. He perceived the formation as saddle-shaped, and added that, although the food cover weavers might find the saddle shape of no use to them, from a mathematical point of view, it would be quite interesting. He was eager to see the woven outcome – which was exactly as predicted: the piece was noticeably saddle-shaped in appearance becoming more pronounced as the framework was filled in. However, all of the weavers were indifferent to this object because it was considered not relevant to their weaving practice. When Aishikin later showed the outcome to the mathematicians, they displayed significant interest in the shape and the underlying mathematical properties that caused the transformation.

The process of mutual interrogation between the weavers and the mathematicians succeeded at least at the level of engagement. This is evidenced by the innovative ideas developed by the weavers in framework construction after the dialogue with the mathematicians. The mathematicians became fascinated by not only the aesthetic values of the food covers, but also by the mathematical structures that are embedded within.

However, the weavers did not interrogate the mathematicians as much as they were being interrogated themselves. The former preferred to accommodate the wishes of the mathematicians by following their suggestions and answering the queries that were posed to them. A possible explanation is the difference in perspectives. Cultural artefacts often evoke feelings of mathematical curiosity in mathematicians, where they try to make some mathematical sense out of the items observed. On the other hand, the weavers generally do not have sufficient mathematical background to develop insights into the abstract world of mathematics. As a result, they did not know what questions should be posed to the mathematicians. Nevertheless, the weavers could see some form of mathematical elements in their practice, and had a deep grasp of the "mathematical" structures of their patterns – in at least one instance this understanding was superior to that of a mathematician.

Carpenters' conceptions

Millroy (1992) was interested in the teaching and learning of mathematics in informal settings. She investigated the mathematical ideas embedded in everyday woodworking activities of a group of carpenters in South Africa. Her focus was geometry because she believed that an understanding of geometric concepts could be expressed through an appreciation of the aesthetic and the creation of a sense of balance in design.

Millroy conducted her fieldwork in a furniture workshop. The beauty and the high quality of the furniture that were made from old-fashioned hand tools convinced her that the carpenters at this workshop must be using geometrical ideas to guide their activities. She wanted to find out what mathematics they used, and where their ideas originated. Except for one person, none of the artisans had received formal training in woodworking. Instead, they had learned in traditional informal apprenticeships, from father to son or by working with more experienced carpenters. Also, all of the carpenters had left formal education early; thus they did not have much involvement with school mathematics.

To prevent herself from describing only those aspects of the carpenters' mathematics that resembled conventional Western mathematics, Millroy decided to become a learner carpenter in the workshop. This decision was based on the assumption that the carpenters' mathematics was socially constructed and communicated through the medium of apprenticeship. She was certain that only through her learning experience as a carpentry apprentice would she be able to find a way to identify and describe tacit mathematical knowledge that she did not otherwise recognise. The knowledge developed through working with experienced carpenters provided her with a way to not only reflect and describe her experience, but also to mathematise like a carpenter. The carpenters taught her using the tools, symbols, and the metaphors of their culture.

Several frameworks were used to view the carpenters' mathematising activities: Bishop's (1998), Krutetskii's (1976), and her own criteria, where she focussed only on activities that were not performed in a rote, mechanical fashion. Other requirements included instances when the carpenters engaged in a cycle of action and reflection on a problem, and their verbal and non-verbal explanation when offering verification or providing critical appraisal of an apprentice's work.

Millroy identified several significant characteristics of mathematising among the carpenters. She found that the carpenters developed concrete, contextual problematics and used physical actions to generate explanation. Mathematical ideas were shaped by the woodworking tools and framed by the context of the workshop.

Her findings showed that many conventional mathematical ideas were implicit in the carpenters' activities, gestures, visualisation and own terminology. Concepts like congruence, symmetry, proportion, straight and parallel lines were used extensively by the carpenters in their activities, but were articulated only upon reflection. The carpenters could generalise the solution of a familiar problem to new situations. They were also innovative and flexible in their methods when constructing novel solutions to unfamiliar problems. However, even though they could discuss abstract ideas, the carpenters used symbols that were different from conventional mathematical symbols.

Having left school early, the carpenters had poor algebraic skills and lacked the knowledge of conventional mathematical algorithms. So they relied on spatial visualisation and their own common sense when solving problems. Consequently, the carpenters' visual and spatial aspects of understanding volume and angles were more developed compared to the numerical aspect of measuring. Visual units that suit specific situations were constructed to solve problems.

The experience of learning to mathematise like a carpenter provided Millroy with valuable lessons. She learned to rely on her sense of touch when determining the quality of a piece of furniture and trained her eyes to develop the ability to visualise. She was taught to compare lengths, check for straightness of a line and whether a surface is horizontal ‘with her eye’. She also learned that in carpentering, rather than measuring, the act of comparing was more direct and accurate in completing a task.

The notions of comparing and measuring in carpentering helped Millroy to attach a practical meaning to her knowledge of the concepts that underlie vector spaces. For instance, putting two planks next to each other in order to find the length of a third plank was analogous to finding the length of an abstract vector space, and choosing a measurement unit was similar to selecting a basis for the vector space. These associations were made upon reflecting on her workshop experience.

Millroy’s documentation of the carpenters’ mathematics was carried out with an aim to make the voice of the latter heard and valued. Millroy’s research can be looked at as a form of mutual interrogation. The interrogation was internal, and the dialogue was conducted between her own mathematical knowledge and the carpenters’ knowledge. But her experience as an apprentice helped her to mathematise like a carpenter and subsequently led her to develop meaningful and significant insights into the mathematical knowledge of the practitioners.

What have we learned about mutual interrogation?

Alangui’s first description of mutual interrogation was little more than a definition and a few suggestions. His own work elaborated, in practise, his method, and showed us its potential. However, as both a mathematician, and as a person with links to the indigenous culture of the practice under investigation, Alangui was able to stand comfortably on both sides of the window and personally experience the mutuality of the interrogation.

In retrospect, we can view Millroy’s experience in a similar vein. As a mathematician, she had her perceptions altered through practical experience. Both Alangui and Millroy undertook a significant period of apprenticeship (or participant ethnography) in the cultural practice of interest. Both were mathematicians allowing their mathematics conceptions to be tested, and both were open to change.

Here, then, is the first lesson we have learned: mutual interrogation can take place *internally* in the mind of the researcher. As a consequence, the success of the methodology, the extent to which either mathematical or cultural practice conceptions may be altered, depends upon the state of mind of the researcher. In this sense, mutual interrogation may be described as an attitude or perspective, rather than as a methodology.

The second lesson, reinforced by Alangui, Millroy, and Adam’s work, is that participant ethnography seems to be an important component of this methodology. It is as if there is a threshold level of familiarity with the cultural practice that is needed before the conceptions of that practice are powerful enough (or internalised enough) to have an effect on the mathematical ones. Perhaps it is a matter of the researcher being confident enough to say “this concept *is* fundamentally different”.

It can be imagined that the need for ethnography is two-way. If the researcher is not a mathematician, then some authentic mathematical experiences are also required. Adam, as a mathematics teacher but not a research mathematician, had this experience. As a member of a Mathematics Department she was constantly interacting with mathematicians, and was able to engage them in sufficiently meaningful discussion to identify when their mathematical ideas were being challenged.

What about external interrogation? Has our experience thus far resulted in a more public questioning of spheres of knowledge? In these three studies external interrogation has been predominantly one-on-one. That is, the researcher has interacted with individuals during the course of their research, questioning them and allowing themselves to be questioned “on behalf of” the other knowledge domain. Millroy’s book is, of course, an attempt to speak to a larger audience, but it is a one-way communication.

There is a third lesson. In order to complete the mutual interrogation the ethnomathematical researcher needs to take on the responsibility of creating a forum which goes beyond individual views. We can imagine that this might take several forms. Appropriate seminars or conference presentations may partly fulfil the requirement, but, like a book, the audience is self-chosen and, unless carefully orchestrated, much of the communication might be one-way.

Does mutual interrogation meet our expectations?

Alangui’s motivation was to find a methodology that allowed a more equal interaction at the cultural boundary between a particular practice and the domain of mathematics. How well has mutual interrogation done this in practice?

Theoretically, we can say that the interrogation was mutual in two senses. In the cases of Alangui and Adam at least, practitioners from both knowledge domains had equal opportunities to interrogate each other (through the researcher). Furthermore, in both cases, the researcher had sufficient understanding of each domain that they were able to communicate with practitioners from either domain in an appropriate way. That is, they could answer questions about the other domain, or carry the questions in an authentic (if translated) fashion. Thus we can say that practitioners from both sides gained a slightly enhanced understanding of the others’ practice during the research study.

But such a statement somewhat avoids the real issue. Did practitioners from both domains have their views altered in significant ways? In the cases of Millroy and Alangui, there is not a lot of evidence that any fundamental changes took place on either side. However, in Adam’s study, which was explicitly aimed at implementing this methodology as deeply as possible, there is evidence of significant change by some practitioners of the cultural practice, but not of the mathematicians.

As a result of her fieldwork, at least one of the practitioners began weaving a completely different kind of object, and has marketed it sufficiently well to continue its production. Furthermore, several weavers experimented with more elaborate designs, both in weaving structure and in surface patterning. They did this independently of the researchers’ questions.

As far as we are aware, no mathematicians spent time beyond the interviews with the researcher in mathematical investigations prompted by the weaving artifacts or analyses. As a researcher, Adam has some unanswered mathematical questions about some structural and patterning issues, and she (with a mathematician's help) generated a novel computer template for triaxial weaving patterns.

We believe that there are some unresolved issues concerning the attitudes of the practitioners of the cultural practice with respect to mathematics, and of the mathematicians with respect to cultural practices. The former hold the mathematics domain in awe (partly, we suspect, from an awareness of their inadequate knowledge of that domain). The latter do not readily accept the potential depth of mathematical interest in a cultural practice (partly, we suspect, from a lack of awareness of their inadequate knowledge of that domain).

If mutual interrogation is to become a significant methodology within ethnomathematics, we need to find ways of addressing both sides of this issue. We need to find a way to ensure that practitioners of two systems face each other with mutual respect, understanding, and ignorance of each others' practices and systems.

Deeper issues and the future potential

Five years after Alangui initially proposed mutual interrogation as an appropriate methodology for ethnomathematical resarch, and after two major attempts at implementing the technique, we are therefore left with three big questions, but considerable hope for the future.

As outlined above, the most important issue is whether equality is really possible between mathematics and a culturally specific practice. How mutual is mutual interrogation: when under the spotlight, does each knowledge domain feel equally confident (or intimidated) as the other?

A second question is whether the interrogation can be expected to proceed to the point where the interrogator can cut their subject free from the bonds that tie them to the chair. The metaphor, in this respect, is apt. It is the interrogator who creates the bonds, the subject only suffers them. The interrogation can be conceived as proceeding to the point where the bonds are no longer necessary to tie the subject down because enough information has been gained.

A mathematician, when observing a cultural practice, creates bonds of perception ("there is no real mathematics in food cover weaving", "any mathematics I observe is present only in my mind", "the weaver has no mathematical knowledge"). The cultural practitioner, when considering mathematics, also creates bonds of perception ("I did not study mathematics beyond school, therefore I know nothing", "I will never understand what the mathematician is saying", "the mathematician will not be interested to understand what it is like to weave"). Will an extended process of mutual interrogation, where mathematician and practitioner take turns interrogating the others' knowledge, ever reach a stage where the perceptual bonds are broken? Will the mathematician gain an enhanced understanding of cultural practices and their relationship to mathematics, and will the practitioner gain an enhanced understanding of mathematics and its relationship to cultural practices?

The third question we have is whether we can really expect advances in mathematics through ethnomathematical research. There are some indications that this may be possible. Gerdes' development of cycle matrices (Gerdes, 2002), and Barton's investigations of double origin graphs (Barton, 2008) are potential examples.

With respect to the future, we believe that:

- Mutual interrogation is not just viable, but an authentic research methodology for exploring connections and differences between mathematics and culturally specific practices.
- Mutual interrogation requires ethnography.
- Mutual interrogation is in need of further testing in diverse situations.

The refinements we see as needing work are:

- Understanding the different levels on which mutual interrogation operates.
- Understanding the role of ethnography in the process of mutual interrogation.
- Finding a way to get deeper into the thinking behind the cultural practice, and this includes identifying the characteristics of mathematical thinking as a backdrop.
- Linking cultural practices with wider aspects of the host culture.
- Finding ways to more deeply involve the mathematical community in this type of thinking.

We look forward to further research.

Notes

[1] See Alangui, W. (2010) *Stone walls and water flows: interrogating cultural practice and mathematics,* unpublished PhD dissertation, Auckland, NZ, The University of Auckland.

[2] See Barton, W. D. (1996) *Ethnomathematics: exploring cultural diversity in mathematics,* unpublished PhD dissertation, Auckland, NZ, The University of Auckland.

[3] Reported in Alangui, W. (2006, February) *Mutual interrogation as an ethnomathematical approach,* paper presented at the Third International Congress on Ethnomathematics (ICEM3), Auckland, NZ.

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