

TABLE OF CONTENTS

TABLE OF CONTENTS	iii
PREFACE	vii
FULL PAPERS	1
Are Unschooled Indigenous People Schooled in Mathematics?	2
Development of Performance Task Activity in Teaching Systems of Linear Equation	11
Weighted Improved Hardy-Sobolev Inequality on a Ball Domain	19
Representations of the Positively and Negatively Subscripted Terms of the AB-Generalized Fibonacci Sequence	29
Domination in the K_r - gluing of Complete Graphs and Join of Graphs	38
Global Offensive Alliances in Some Special Classes of Graphs	43
The Use of Computation Journals in Reducing Low Achieving Students Errors in Algebraic Rational Expressions	49
Students Level of Understanding of the Basic Concept of Functions and Relations: A Conceptual Analysis	54
Roman Domination Number of the Join and Corona of Graphs	66
The Relationship of BF-algebras and Groups	70
Students Misconceptions in College Algebra	76
PLENARY TALKS	81
Plenary Talk 1	82
Dr. Fe Annabel N. Yebron Department of Mathematics, Central Mindanao University, Musuan, Bukidnon <i>“Are Unschooled Indigenous People Schooled in Mathematics?”</i>	

Are Unschooled Indigenous People Schooled in Mathematics?

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INTRODUCTION

I would like to illustrate the answer of this question using the study that was conducted by me and Dr. Rolito G. Eballo with some faculty members of the Department of Mathematics of the College of Arts and Sciences of Central Mindanao University in Musuan, Bukidnon.

This study was inspired by the statement of a Brazilian mathematician Ubiratan D'Ambrosio, in the late 1960's that mathematics refers not only to symbolic systems but also to concrete physical practices or activities such as **ciphering, measuring, classifying, ordering, inferring, and modelling** by identifiable cultural groups. It may be used specifically with regard to the **thinking patterns** and practices in small-scale indigenous societies. This term is ethnomathematics.

Edward Dolnick in his book entitled *The Clockwork Universe* stated that the scientists in the 17th century firmly believed that God, the greatest architect, has written His laws in a mathematical code. The task is to find the key to "read God's mind" in order to understand the universe.

Perhaps the most powerful claim for mathematics as a new discipline has been made by D'Ambrosio himself (quoted in the *Chronicle of Higher Education*, 6 October 2000).

"Mathematics is absolutely integrated with Western Civilization which conquered and dominated the entire world. The only possibility of building up a planetary civilization depends on restoring the dignity of the losers and together, winners and losers, moving into the new. Ethnomathematics, then, is a step towards peace."

A postcolonialist theory about the intersection of mathematics, education, and politics is to challenge academic mathematics in order to enable the revision of school curricula by (re)locating and (re)embedding the objectives, content and methods of mathematics education in the cultural environment of learners (Horsthembes, 2005).

Approaches that take into account the cultural context and the mathematical systems in use within the community are likely to be much more effective. Some researchers reveal that much of the mathematics used in daily practice, as affected by distinctive modes of cognition, may be quite different from that which is taught in school. Connecting the mathematics lesson with what students see in the environment or do in real life is a very meaningful teaching strategy to effect permanent learning.

BACKGROUND OF THE STUDY

The ethnic groups in Bukidnon are very strong in their desire to preserve their cultural heritage. Considering the interesting local history of the Matigsalug, the Matigsalug tribe was chosen for the pilot study.

Using qualitative data collection, this study sought to **describe some of the material culture and customary practices of the Matigsalug people in terms of mathematical concepts and symbolic systems to show the richness of the Matigsalug culture, and for preservation purposes.**

Since the traditional practices of their culture were the focus of the study, the key informant method in gathering data was used, supplemented with participatory interview method and focus group discussion.



Significance of the Study

Ethnomathematics is a relatively new area of mathematical research. Documenting the local history and cultural practices of the Matigsalug tribe in terms of mathematical concepts is one good source of interesting information for the writing of supplementary materials and/or the revision of instructional materials and the preservation of the indigenous culture of the Matigsalug people amidst culture changes.

REVIEW OF RELATED LITERATURE

Conceptual / Theoretical Framework

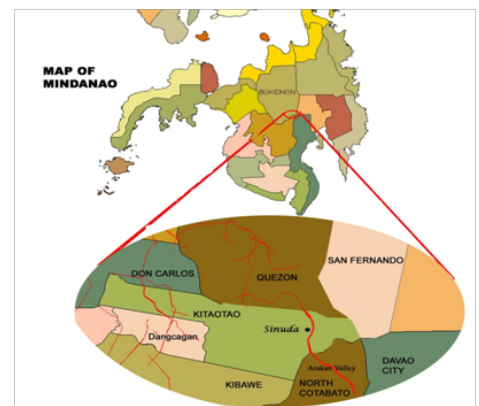
What is a mathematical occurrence? It occurs when the idea of correspondence or the principle of association is employed. Since ideas are abstract, by nature, mathematics is a science of abstract objects. Whenever mathematics or mathematical ideas are expressed, the following elements are involved, namely: numbers, figures/forms, structure, algorithm, chance, and change. The physical representation of these ideas entails proper arrangement of things. Thus, making mathematics as a science of order and pattern.

In terms of its role, mathematics is a universal language. It was the symbolic language of the ancient, medieval, and modern times embedded in the culture of the people and expressed through writings in the caves, designs in potteries, songs, dances, poetry, and the like. Collectively, the different powerful descriptions make mathematics as the foundation of truth and the standard of certainty.

THE RESEARCH DESIGN

The Setting

The Matigsalug are indigenous people belonging to the Manobo group. Based on oral tradition, they descended from their great ancestors such as Apo Tulalang (Matigsalug hero), Apo Mungan (heroine) and Apo Agyu (Bukidnon hero). They originally lived along the watershed of Tigwa and Salug Rivers within the Municipalities of Kitaotao and San Fernando, Bukidnon, and along the mountain ranges of



Barangay Sinuda and its neighboring municipalities

Bukidnon-Davao border. The word “matig” means “inhabitants of” and the word “salug” is referring to the Salug River. Hence, Matigsalug means inhabitants along Salug River. Salug River is now popularly called Davao River.

Today, Sinuda is the biggest barangay with 22 sitios, in the municipality of Kitaotao, Bukidnon. It is densely populated by the Matigsalug. It is situated along the national highway between the boundary of Bukidnon and Davao provinces. It can be reached by bus either from Bukidnon or Davao City. (Lifted from the 2001 poster presentation of Dr. V. Suminguit entitled “A Glimpse of the History and Culture of the Matigsalug Tribe”).

Methodology

Before the research team was allowed to conduct the study, series of entry protocols had to be complied with which included rituals. The team had to face the officers of the Federation of Matigsalug-Manobo Tribal Councils or FEMMATRICS for almost a day answering questions from about sixty Matigsalug. The preparation of a Memorandum of Agreement (MOA) in Cebuano and in English was also required. It took us months to draft and finalize the MOA since every word and sentence was scrutinized.



Datu Jose Dia-on, Datu Manuel Lacaran, and Datu Tukling Tawas, Primary Informants of the Study

Since the traditional practices of their culture were the focus of the study, the key informant method in gathering the data was used. The informants were the tribal elders called **datu**. The elders are regarded by the community as the source of reliable information and respected authority. They are regarded as the keepers of the lore and traditions of the community. They are expected to define correct customs, interpret procedure, and remember significant matters from the past. In this study, the main informants included the **datu**s who fought in the uprising for the recognition of ancestral domain.

Pictures of traditional clothing, personal adornment and accessories were taken. The participatory interview method was utilized upon the artists and makers of these materials and with the community elders by the research aide who in turn submitted written reports to the study leader. These are then validated by the researchers in another series of participatory interviews which were taped, recorded and videotaped.



(Clockwise from Top-Left) The *Tangkulu* (headgear), *Tabbed* (belt) and *Ilab* (curved knife), the *sening* (beltbag for men and women), and the women’s *balaring*.

THE ETHNOMATHEMATICS OF THE MATIGSALUG TRIBE OF SINUDA, KITAOTAO, BUKIDNON

Problem 1. How have the Matigsalug tribe come to understand, comprehend, articulate, and ultimately use mathematical ideas, concepts, and practices that may solve problems related to their activity?

Means of Communication and Transmission

As pointed out by the oldest of the living spiritual leaders (Datu Tawas, 101 years old), the socio-cultural practices of the Matigsalugs originated from the 'start of the world'. These are exactly transmitted orally and clearly to the community from generation to the next generation, even if the tribal leader has no formal schooling. He said it with conviction because customary laws which are the basis of their cultural practices are intertwined with belief system involving the unity among nature, human beings and the spirit world. The Mathematics referred in these are illustrated in the meaning associated with the colors, geometric shapes, and their placement in their traditional clothing, personal adornment, accessories made from natural materials; dances, songs and customary practices. The requirement of rituals in any major activity for collective memory helps **sustain the reciprocal relationship** among the people and the land and the spirits.

Love for Peace and Harmony - Strong Spirituality

The Matigsalugs strongly believe in environmental and ancestral spirits and *Manama/Magbevayè* (sole deity). Everytime a major activity or decision has to be made, the Matigsalugs through their elders and leaders consult the spirits and *Manama/Magbevayè* for they believe that they are the owners of the land and its resources. Consultations take the form of rituals, which may include praying, chanting, singing, dancing, killing of animals such as chickens and pigs, wine-drinking and food-sharing during the communal meal usually at the end of the ritual. The spirits may select the place as their abode, so it becomes a sacred place. Thus, the people are enlightened as to the proper steps to follow to achieve peace and harmony in the resolution of a conflict.

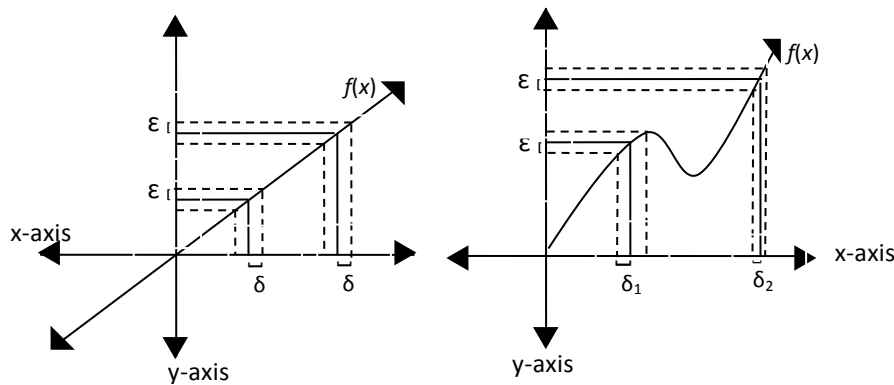
In the context of resource management rituals may be considered a planning tool towards effective means of communication and learning.

The foregoing illustrate that the **thinking and reasoning** of the Matigsalugs have **order and pattern** which is a basic description of what is mathematical.

Their abiding faith in the spirits and Manama as anchors of their actions for peaceful resolution illustrates the mathematical concept of 'uniform continuity.' Uniform continuity is defined, by Buck, as:

We say that a function f is **uniformly continuous** on a set E if and only if, corresponding to each $\varepsilon > 0$, a number $\delta > 0$ can be found such that if $|f(p) - f(q)| < \varepsilon$ whenever p and q are in E , and $|p - q| < \delta$.

Fig 7. An illustration of uniform continuity (left) and local continuity (right).



An Illustration of uniform continuity (left) and local continuity (right)

In this case, δ refers to their uniform actions for peaceful resolution ϵ . Their faith would not waiver under any circumstances.

Examples of CIPHERING, Measuring, Classifying, Ordering, Inferring, Modelling

Codes	Symbolisms / Representation	Codes	Symbolisms / Representation
Colors		Numbers	
Black	Past, problems	1	Oneness, clear, single-mindedness
Red	Bravery, struggles, leader	2	Good or bad, not clear, not complete
White	Peace and order, harmony, enlightenment, purity, obedience	3	Feminine, kitchen owner
Yellow	Light, sunrise/sunset	4	Structure, the four directions
Shapes		5	Strong
Diamond	Heart	6	Relaxed, confident, sure
Square	Sacred, not to fight	7	Manama (sacred number)
Parallel lines	Objectivity, justice, fairness	8	Plenty, towards a circle (the limiting process in calculus)
X	Promises which are not to be broken	Inventions	
Adornments		<i>Ilab</i>	Knife for men
<i>Tangkulu</i>	Headgear, worn by datus/leader only	<i>Gepes</i>	Knife for women
<i>Sangkad</i>	Headdress worn by wives of datus only	<i>Ginan</i>	Animal trap
<i>Hinavel</i>	Lady skirt out of abaca fiber	<i>Balatik</i>	Trapping wild pigs
<i>Binelaran</i>	Traditional clothing for wives of datus	<i>Balatik te uval</i>	Trapping monkeys
<i>Pula na binekad (jacket)</i>	Worn by warriors/leaders	<i>Balatik te usa wey bavuy</i>	Trapping deer or pig
<i>Itum nga binekad</i>	Worn by ordinary people	<i>Kalasang teg bevasbas</i>	Shield for amateurs
		<i>Kuving</i>	Instrument for serenading

Problem 2. How are local practices and solutions of problems developed into methods?

Solutions of problems are part of the accumulation of traditional knowledge and experience that links humanity with its ancient origins through their community elders. Standard rules and procedures are followed. They believe that violation of these rules may bring about illness or death or poor harvest to the violator. Compliance with the rules derives from the internalization of the belief, thus making external coercive force unnecessary.

Telling day of appointment through *kerew* (calendar) – One-to-one correspondence

Many of the elders have no formal schooling, some don't even know how to write and read.

Determining the day for an important appointment is done through a bundle of rattan sticks. The number of sticks is equal to the number of days in the agreement. Each agreed party has the same kind of bundle. Each day that passes, a stick is removed from the bundle. No stick to put away means it is the day of appointment.

Telling time through natural clock – Ciphering / Principle of association

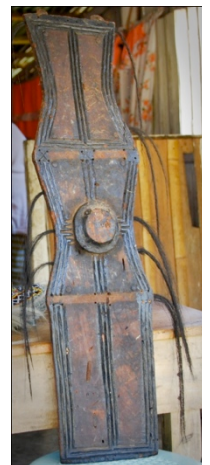
- *Pameket o beket tungtung* - The presence of fireflies means it is time to put away things and prepare for the night. It is 6:00 in the evening.
- *Mangitat kulis* - The lines on the palm can be seen. It is time to cook supper. It is 6:30 in the evening.
- *Pakilaleeyt talaari* - The face of a non-member of the household cannot be recognized, only the faces of the household members. It is 7:00 in the evening.
- *Bigtas te maralem* - There are no more people outside the house. The people inside the house are already sleeping. It is about 8:00 – 10:00 in the evening.
- *Liware* - Crickets stop to make noise. Their noise is likened to the breath of the night. Old people start to be awakened. It is 12:00 midnight.
- *An-anayan neg ukale ka manuk* - The first crow of domesticated and wild roosters is at 1:00 in the morning.

Non-standard measurements:

- For length: arm span, ell (meter), hand span, toe length, waistline, height, head height, body size, hand size, head size, feet length, leg size
- For volume: *gamak* (1 handful), *akup* (2 handfuls), *pindut* (pinch)

Dancing (right) - The basic dance steps are structured into four steps to the right, then 4 steps to the left, move forward and make 8 steps to form a circle. The number 4 means durability, 8 means eternity, and circle means harmony.

Kalasag teg bevasbas (far right) – shield for beginners; 3 hand spans wide, 3 inches thick, length is waistline high.



Since the height of a Matigsalug ranges from 4 feet 5 inches to five feet, a hand span is 6 inches long, waistline height is 30 inches. It is a **golden ratio**, having the most pleasing proportion.

Conduct of meetings

It could be observed that every time the research team is required to face the FEMMATRICS, the following is observed: The tribal and spiritual leaders sit in front with the Chair of the Council acting as the presiding officer. A spokesperson facilitates the introductions and act as the moderator. A prayer is said by a datu with open eyes, singing and dancing is done before the ritual is done. This is followed by question and answer portion. Lastly, food is served by the spokesperson **equally** to all who are present.

Problem 3. How are methods developed into theories?

Unknowingly the Matigsalugs employ the **decision theory** in administering justice. The process involved is long and tedious and is administered with patience. Objects in the environment are used as tools to indicate certain conditions that are used as basis for the choice to make by the parties concerned.

On Some Observable Patterns in their Tribal Costumes

In all the tribal costumes used by the Matigsalug in Sinuda, symmetry and order have been observed. Regularity has also been observed in most part.

For the upper part of the men’s costume, the *binekad*, a base cloth with only one color is used (either red or black), upon which many vertical and horizontal stripes of different colors are added. Inside the boxes created by the vertical and horizontal stripes are some geometric configurations (or motifs) made up of rhombuses or diamonds. The stripes and the motifs are symmetric with respect to line L which is the vertical line at the center; these are orderly attached to the base cloth, whose edges are also decorated with colourful cloth linings which are straight in some portions and regularly zigzag in others.

What is probably worthy to note is the horizontal regularity of the motifs appearing in the boxes created by the intersecting vertical and horizontal stripes in most of the men’s *binekad*. Algebraically, this falls under one of the 7 frieze patterns. Other than this, there are no other frieze patterns observable in their present tribal costumes, including the men’s short pants, and the women’s *binalaran*.



The upper part of the women’s *binalaran* and the men’s *binekad*



The *kiving* (top), and bird trap and basket (bottom)

Problem 4. How are theories developed into scientific invention?

The Matigsalugs claim to have many inventions, such as the various musical instruments, animal traps, shields, fish catcher, bird catcher. For lack of material time, the mathematical theories embedded in these inventions have not been looked into.

CONCLUDING REMARKS

The socio-cultural practices of the Matigsalug people are similar to that of the ancient times as recorded in the history books in mathematics. It is a proof that mathematics is a universal language. It was the symbolic language of the ancient, medieval, and modern times embedded in their culture.

The Mathematics referred in this study were illustrated in the meaning associated with the colors, geometric shapes, and their placement in their traditional clothing, personal adornment, accessories made from natural materials, dances, songs, and customary practices. The requirement of rituals in any major activity for collective memory helps sustain the reciprocal relationship among the people and the land and the spirits. Fundamental to analytical mathematical concepts were illustrated in their cultural practices. Some observable patterns were seen in their tribal costumes that would speak of their way of life advocacy of moral values. To live peaceably is to harmonize with nature.

Mathematics as a science of order and pattern is embedded in their concrete physical practices or activities as well in their symbolic systems.

Although they are less schooled, their strong adherence to the spirits as owners of the land and its resources, make them think, reason and behave as if “all they really need to know, they learned in kindergarten (adapted from Robert Fulghum).

RECOMMENDATION

Hopefully, the output of this study may also serve as basis for writing supplementary instructional materials in mathematics to achieve relevance and meaningful learning experiences.

REFERENCES

- Barton, B. (1996). Making Sense of Ethnomathematics: Ethnomathematics is Making Sense. Educational Studies in Mathematics, 31(1-2), 201-33.
- Bennagen and Lucas-Fernan. (1996) Editors. Consulting the Spirits, Working with Nature, Sharing with Others.. Sentro Para sa Ganap na Pamayanan, Inc.
- Buck, R. C. (1978). Advanced Calculus Third Edition. McGraw-Hill, Inc.
- D'Ambrosio, U. (1985). Ethnomathematics and its Place in the History and Pedagogy of Mathematics for the Learning of Mathematics, 5(1), 44-48.

- D'Ambrosio, U. (1992). Ethnomathematics: A Research Programme on the History and Philosophy of Mathematics with Pedagogical Implications. Notices of the American Mathematics Society, 39, 1183-85.
- D'Ambrosio, U. (2003). Stakes in Mathematics Education for the Societies of Today and Tomorrow. (In Proceedings of the EM-ICMI Symposium.)
- Dolnick, Edward (2011). *The Clockwork Universe*. New York: Harper Collins.
- Flores, P. V. (2000, November). Ethnomathematics: From Abel to Tinalak: The Philippine Indigenization Approach to Teaching, Monograph 63. National Institute for Science and Mathematics Education Development, University of the Philippines, Diliman, Quezon City.
- Horsthembes 2005.
- Milton, R. (2000). From the Reality to Mathematical Modeling: A proposal for Using Ethnomathematical Knowledge. Unpublished Master's Thesis. Department of Teacher Education, California State, Sacramento.
- Teresi, D. (2002). *Lost Discoveries: The Ancient Roots of Modern Science – From the Babylonians to the Maya*. New York: Simon and Schuster.
- The Faculty of the Discipline of Mathematics, University of the Philippines College Baguio. (1996). *The Algebra of the Weaving Patterns, Gong Music and Kinship System of the Kankana-ey of Mountain Province*. Department of Education, Culture and Sports, Bureau of Non-Formal Education, Republic of the Philippines and Education Research Program, Center for Integrative and Development Studies, University of the Philippines.

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