THE INVENTION OF ETHNOMATHEMATICS:

THE SOCIAL HISTORY OF A FIELD

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CERTIFICATE

This is to certify that the dissertation entitled **The Invention of Ethnomathematics: The Social History of a Field** submitted by Urmila Unnikrishnan in partial fulfilment of the requirements for the award of the degree of Master of Philosophy of this university is her own work and has not been submitted so far, in part or in full, for any other degree or diploma of this or any other university or institution.

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Chapter 1

Introduction

This dissertation makes an attempt to arrive at a historical and sociological appreciation of the evolution of the field of ethnomathematics, the kinds of mathematical activity that the field has come to designate and the kinds of disciplinary and institutional dynamics that it embodies. Embroiled in the politics of scientific knowledge and informed by the concerns for democratization of knowledge, ethnomathematics constitutes a field premised on a postcolonial discourse theory of knowledge production and dissemination. Furthermore, when located in its institutional and disciplinary context, it is possible to determine the potential of a cognitive resonance to usher major pedagogical reforms.

1.1 Background of the Study

The term ethno has gained currency in almost all disciplines. It proposes a different perspective to look at social/natural phenomena which were hitherto viewed from only one perspective that was predominantly a European, male perspective. Ethnomathematics also forms part of this new way of perceiving. An understanding of the development of the field is important because more than other ethno fields, it has large educational implications. The development of ethnomathematics has to be understood against the background of several converging trends which is organised in the following discussion under two broad sections-the emergence and development of the discourse on ethno and the concurrent debates in the field of mathematics education.

1.1.1 Discourse on Ethno

"Every epoch has its fundamentally new approach and its characteristic point of view, and consequently see the 'same' object from a new perspective" (Mannheim 1936 p.243).

The 'other' has always been an important category in social theory, and defined the conceptual frame of colonial anthropology and history. But by the last quarter of the twentieth century the discourse on the "other" started to take new directions. This was driven by several developments in social theory as well as other political developments. Verran and Turnbull (1995) give a very lucid description of the various stages of the discourse on the 'other' in science and technology studies. Their argument can be extended to other realms of social theory as well.

According to Verran and Turnbull (1995) during the first phase, studies on non-Western societies were mainly carried out with an aim to define western society in contrast with others. Western rationality and objectivity were taken as the criteria for defining all knowledge systems. These were 'accounts of dichotomy' as Verran and Turnbull call it, where the "great divide in knowledge systems coincided with the great divide between societies that are powerful and those that are not" (p.116). During this phase the "so called traditional knowledge systems of indigenous peoples have frequently been portrayed as closed, pragmatic, utilitarian, value laden, indexical, context dependent and so on implying that they cannot have the same authority and credibility as science because their localness restricts them to the social and cultural circumstances of their production" (ibid). This approach to knowledge portrayed western science as decontextualised, and the portrait dissolved with the emergence of a contextualist approach in the second phase which was more egalitarian also. The new framework laid explicit focus on the local.

In the second phase science was seen as social action and it was argued that "though knowledge systems may differ in their epistemologies, methodologies, logics, cognitive structure or socio-economic contexts, a characteristic that they all share is localness" (ibid). Western techno-science rather than being taken as the benchmark for defining knowledge, rationality and objectivity, was taken as yet another variety of knowledge system (Verran and Turnbull, 1995). The change in perspective towards non-Western societies and their knowledge systems was driven by the developments in a wide range of disciplines including anthropology, history, sociology, political science, philosophy and even economics, all derived from and directed towards a postcolonial, postmodern understanding of society and social theory.

Raina (2003) attributes the development of these 'reflexive discourses' to several political developments in later half of 20th century. The Post World War II era, marked by several political and social changes contributed to the reflexive discourses by challenging the hegemony of Europe. The rapid dissemination of literacy brought the social production of discourses into focus. This was corroborated by a disenchantment with modernity and a revived confidence among the newly independent nations (ibid). The political as well as the intellectual supremacy enjoyed by Europe was shaken. The centrality of Europe as a site for knowledge production was questioned. A more critical perspective that analysed the role of colonial encounters in the process of knowledge production. Modernity and its paraphernalia were the major targets. In other words "the dialectic of enlightenment had now moved towards the critique of modernity and its most potent symbol, science" (ibid p. 3).

Postcolonial science studies argued that Western science is just one among the many ethnosciences (Harding 1992). It challenged the claim of universality and dominance of western science and envisioned the development of "fully modern sciences within the cultural legacies and progressive political tendencies" (Harding 1992 p.311) of the Third World. From the post-colonial vantage point Harding explored the multicultural nature of science (Harding 1998). She exposed the myth of western science being autonomous and different from other forms of knowledge and demonstrated how the science which claims to be western is in fact an amalgam of various knowledge traditions from around the world, which the Europeans exploited and appropriated during colonial expansion. This proposal of a multicultural nature of science provided scope for standpoint epistemologies (Harding 1996). Standpoint epistemology is based on the argument that the dominant western science is based on a standpoint informed by imperialistic and patriarchal ambitions and hence it is unable to understand all aspects of the phenomenon under study (ibid p.148). Therefore they proposed a standpoint of the so far under-privileged. They argued that "socially advantaged people and their institutions are in fact epistemologically disadvantaged and that social disadvantage creates a certain kind of limited but important epistemic advantage" (ibid p.146), which can throw light on many aspects of life and knowledge which were obscured by patriarchal, imperialist western science[1]. Feminist philosophers of science developed a feminist standpoint epistemology and left open the scope for standpoint of tribal, of lower caste and classes and so on.[2]

Discourses on indigenous knowledge, received impetus from alternative developmental perspectives (Oomen 2000) and economic studies of knowledge (Sengupta 2007). Alternative developmental perspectives questioned the mainstream developmental perspective and the paradigm of science and technology that informed it. The global environmental and climatic crisis gave impetus to it. The United Nations Conference on Environment and Development, 1992 proclaimed, "indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement

[1] Raina (2007) points out that Harding misses out the diversity of post colonial project. He argues that "postcolonialism is not monolithic, and if so it could well be that there are strands in its fabric that are not multicultural either, and are the very image of the Eurocentric discourse that postcolonialism has ostensibly challenged" (p.178).
[2] Longino (2005) puts up a similar critique of feminist standpoint theory and suggests an approach that focuses on 'science as practice rather than content, as process rather than product' (p.2). She argues that the diversity and complexity of the category women makes it difficult to generate any single cognitive framework.

of sustainable development" (Rio Declaration Principle 22 quoted in Rangarajan 2007 p.13).

Sharing a similar paradigm, the economic studies of knowledge, proposed to utilise indigenous knowledge to meet the needs of largest number of people without tinkering with sustainability. [3] Several works explored high utility as well as sustainability. However this utility approach on indigenous knowledge was received with scepticism. Drawing a parallel between colonialism and present day imperialism driven by the World Bank and International Monetary Fund, Harding (1992) observes that "western sciences and technology are deeply implicated in increasing the gap between haves and have-nots in the third world and the world economy, in appropriating non-renewable Third World resources for the benefit primarily of already economically advantaged Westerners, in turning productive local ecologies that were capable of supporting their indigenous populations into wastelands capable of supporting no life at all" (p.314).

This period combined the critique of science with capitalism and state. Vandana Shiva (1990) argues that western science is *reductionist* and is a kind of 'epistemic violence'. She sees science as intimately related to state and the power of science as deriving from the power of the state. Shiva with Mies (1993) proposed an ecofeminist perspective and advocates a science from the standpoint of women which can ensure harmony with nature. [4]

Shiv Vishwanathan also pointed to the hegemonic nature of science reflected in the theory of transfer of technology. He argues that "transfer of technology is the theory of development that sees science as travelling from the centre to the periphery, metropolis to province.....unlike science other sources of knowledge are seen as ethno science, superstition or more brutally non-knowledge" (2009 p.49). He exposes how Western science appropriates any

[3] It should not be understated that this interest in indigenous knowledge was mainly focused in areas like agriculture, food practices, medicinal systems, fisheries management etc.
[4] Shiva has been criticised from various quarters for essentializing the women-nature relationship and thus inciting the earlier nature/culture debate.

valuable or useful fragment of knowledge and codifies in it in a way that the knowledge now becomes alien to the cultural group that generated it. The solution to this hegemonic science is sought in public participation. He envisions a republic of science where all the hitherto marginalised natives of science will have equal rights and equal say. He (2001) gives a call for re-entering of the question of science and technology into the public sphere.

New social movements and ecological movements also supplemented the arguments (Shiva 1990). While ecological movements challenged the logic of development; new social movements directed attention to the nexus of science, capitalism and state. Viswanathan (2001) also points out to the importance of science popularisation movements in democratising science.

Gaining from these developments the discourse on 'ethno' gained currency in the sociology and history of knowledge and new concepts like ethnobotany, ethnochemistry, ethnoastronomy etc. began to evolve.

1.1.2 Mathematics Education

Alan Bishop begins his book *Mathematics Enculturation, 1991* by pointing out that mathematics is the most important school subject, as well as the least understood one. Mathematics is an important and integral part of our everyday life and culture, perhaps more so than any other school subject. Yet it is a nightmare for many students, even for those who perform very well in other subjects. "It is socially quite acceptable in many countries to confess ignorance about it (mathematics), to brag about one's incompetence in doing it and even to claim that one is mathophobic" (Bishop 1991 p. xi). One of the SMS jokes recently circulated among high school students in Kerala is that MATHS stands for Mental Attack on Healthy Students. Though a joke, it captures the perception of mathematics among students. The question arises that if mathematics is so important and interesting then what makes the students fear it? The research on mathematics education points out that the root cause is the existing mathematics curriculum and pedagogy does not respect the child's socio-cultural background.

As Bishop puts it the current curriculum aims at teaching students to 'do' mathematics, i.e. it emphasizes knowledge as a way of doing (Bishop 1991 p.3). For many students mathematics is only a mechanical process of rote learning formulae and steps involved in solving a problem, practicing it and reproducing it in the exams. Against this Bishop proposes a mathematics education which is concerned with a 'way of knowing' (ibid)-an idea that underlies ethnomathematics also.

However, the emergence of ethnomathematics as a perspective in mathematics education cannot be understood as an immediate effect of the reflection on the failure of the subject to interest student at schools. Rather, it has to be understood through the debates in mathematics education that has shaped the field in the present form.

D'Ambrosio (2000) traces the changes from the 19th century to the contemporary stakes in mathematics education. The beginning of the 19th century was marked by a change in the social order. New modes of production demand new skills for labour, and change in the social structure. Developments in psychology and insights into child psychology gave impetus to the new discourse on education. "The new educational thinking called for updated mathematical content, as well as for new methods of teaching, reflecting findings in learning" (p.304). The motivations of students emerged as an important category in the discourse on learning. Mathematics was fundamental to the new developments in technology and hence fundamental to the new demands of labour. A complementary development in the discipline of mathematics resulted in a 'formal and structured organisation of curricula'. More drastic changes were in place after the Second World War. The emergence of technoscience, new economic priorities and the newly found interest in defence and military research gave mathematics the status of the most important discipline and this called for reforms in mathematics education which was also backed by contemporary developments in theory of cognition.

The Cold War contributed to the disciplinary expansion of mathematics as expenditure on defence and scientific research increased. The demographic changes during the post war period-immigration and emigration changed the demographic profile of the nations and issues of multiculturalism and multilinguism drew attention. Social exclusion and the role of education in both preserving and changing the status quo were widely debated (D'Ambrosio 2000).

"Till the end of the school year 1957/1958 school mathematics was quite the same everywhere. Primary school mathematics mostly consisted of arithmetic, secondary school mathematics was mostly algebra and plane Euclidian geometry, and in the upper grades algebra, analytic geometry, solid Euclidian geometry and trignometry. In the 1950s, calculus teaching spread in upper secondary schools" (Malaty p.231).[5] The launch of Sputnik in 1957 was greeted by an invigorating interest in mathematics and mathematics education. An era of 'New Maths' was inaugurated in US which envisaged a change in curriculum and pedagogy of mathematics education to meet the new demands. At the Rayaumont Seminar of 1959, the slogan 'Euclid Must Go' raised by Jean Dieudonne resulted in radical changes in mathematics education. New Maths became a larger movement covering the rest of the West and spread to the Third World as well. However, the New Math movement failed to make any drastic impact and was criticised vehemently both by the public and some section of mathematicians. It was criticised for deskilling the students' mathematical/arithmetical abilities. Finally by the mid 1970s new maths movement gave way to the "back to basics" movement which attempted to be a counter movement to the new maths movement. The back to basics movement put emphasis on basic arithmetic skills and on the structure of mathematics education (ibid).

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[5] http://math.unipa.it/~grim/EMALATY231-240.PDF Accessed on 03/03/11.

The failure of mathematics education was reflected at different levels. The lack of interest of students in mathematics and their consequent failure in the subject, the failure or low level of performance by students belonging to certain cultural groups like girls, tribal students, students from lower caste/class background; low level of student enrolment in mathematics at university level and the inability of the students to make any connection and use of their mathematics learning to their everyday life all called for reflections on the various aspects of mathematics education. (Bishop 1988, 1990 and 1994, Malatay,[6] Panda 2006, Lloyd et.al 2005, Seegers and Boekaerts 1996, Frankenstein 1990, Walkerdine 1990). Ethnomathematics emerged as a result of similar concerns about the mathematics education.

1.2 Research Problem

Ethnomathematics is a transdisciplinary field of study, the development of which can be traced back to Ubiratan D'Ambrosio's 1984 plenary lecture at the Fifth International Congress on Mathematics Education in Adelaide, Australia. Ethnomathematics is grounded on the basic premise that mathematics as we know and understand it today is largely a Western construct and that there is mathematics beyond the conventional academic mathematics. Ethnomathematics argues that this mathematics lies embedded in the socio-cultural life of people and can be reconstructed to form a basis for mathematics education. It also helps to challenge the Eurocentric biases in history and philosophy of mathematics and mathematics education.

The idea of socio-cultural roots of mathematics and the Eurocentric biases of academic mathematics was already known and debated. But D'Ambrosio' Adelaide lecture was instrumental in bringing together these ideas and in the development of a research field called ethnomathematics. With his lecture the term began to be widely used in the literature on mathematics education and

[6] http://math.unipa.it/~grim/EMALATY231-240.PDF Accessed on 03/03/11.

its socio-cultural aspects. The formation of International Study Group on Ethnomathematics in 1985 led to the institutionalization of the field.

Ethnomathematics provided a new perspective that gave importance to the cultural as well as the historical aspects of the subject and to that of the learner. Apart from the immense educational implications, ethnomathematics also implies a change in perspective on mathematics and raises several social and political issues like Eurocentricism, hegemony, multiculturalism, cognitive justice, right to cultural heritage etc. not to mention internal mathematical issues like the ontology of mathematical knowledge, the plurality of protocols of resolution, the varying representations of mathematical entities and realities.

1.3 Theoretical Background

Sociological literature is replete with theoretical frames that can guide an inquiry into the complex of indigenous knowledge. Levi- Strauss' idea (1966) of bricolage and Marglin's (1990) distinction between episteme and techne are just examples. However, this study is not about indigenous knowledge per se, but about a field of study that studies ethno (mathematical) knowledge. In that sense, it falls into the realm of sociology of knowledge and social theory of science. The study derives insights from sociology of knowledge and is based on its principal thesis that modes of thought cannot be fully comprehended without an understanding of their social and historical genesis (Manheim 1929). The evolution of the field of ethnomathematics is understood as part of the social and intellectual dynamics of the period. Social theory of science furthers the pursuit of sociology of knowledge to natural sciences. It maintains that science has to be understood in its practice contrary to the normative explanations that hitherto characterised the meta-theorizing of science. It locates science within the historical discourse about science and explores the socio-political factors that contribute to the production of scientific knowledge (Raina 2003).

In this study the field of ethnomathematics is conceived as part of the larger academic space. Development of ethnomathematics is integrally related to the dynamics of the larger socio-political and academic site of production of discourses and the negotiations and manipulations within it. The following section examines some of the relevant works that provide insights for the present pursuit.

1.3.1 Clifford Geertz- Ethnography of Thought

Insisting on the imperativeness of ethnography of modern thought Geertz (1983) observes that "various disciplines-humanistic, natural scientific or social scientific alike are ways of being in the world" (p.155). "In the same way that Papuans or Amazonians inhabit the world they imagine, so do high energy physicists or historians of the Mediterranean in the age of Philip II-or so, at least, an anthropologist imagines" (ibid). He comments on the need for an intersubjective connection between various disciplines for ethnography of modern thought and goes on to elaborate on the methodological themes in anthropology that would be relevant for such a project. He picks up three methodological themes in anthropology.

- The use of convergent data
- The explication of linguistic classification
- The examination of life cycles

According to Geertz most effective academic communities are "not much larger than most of peasant villages and are held together by a kind of Durkhiemian solidarity. The relationship among the members of these 'intellectual villages' is not merely intellectual, but also moral, political and to some extent personal. For Geertz, the convergent data gathered from these 'units' (intellectual villages) can help to build an ethnography of modern thought.

Geertz's second methodological theme-the explication of linguistic classification- aims to focus on the key terms used within different intellectual villages. According to him, the "vocabularies in which various disciplines talk about themselves to themselves" (p.159) is an entry point to the 'sort of mentalities at work in them' (ibid). These key terms represent the aims, judgements and justification of that particular intellectual pursuit and thus form an inevitable addition to the ethnography of thought.

The third methodological theme-the examination of life cycles suggests two very important points of reference in understanding any community. One is the career pattern of the disciplines, or in other words, the pattern of induction into the community. Geertz (ibid) observes that, in the academic community "one starts at the centre of things and then move towards the edges" (p.158). Majority of doctorates in any academic discipline are produced in primarily seven or eight universities which form the core/centre of that community. But all those persons who receive doctorates at the centre are not placed at the centre itself. The peculiar induction patter of academic communities gives unique insights on the shaping of mentalities and the ritual lives in these communities.

The second important point while examining the life cycle of academic communities is the age structure or 'maturation cycles' in various scholarly fields. Geertz gives examples for these maturation cycles- "mathematicians who seem to blossom at eighteen and be washed up at twenty five and on the other hand is history where fifty year old men are sometimes thought to be still not mature enough to tackle a major work" (p.159). "This 'natives' notion about maturation (and postmaturation) in various fields, together with the anxieties and expectation those notions induce shape, much of what any given one is like, 'mentally' from inside" (pp.159-160).

Geertz' methodological premises are important and Trowler and Bechler (2001) have used it as their vantage point in their ethnography of higher education. However, ethnomathematics being an emerging discipline is not more than twenty five years old one cannot actually attempt to understand the field looking at the life cycles. Similarly, the methodological theme of explication of vocabulary is also of not much help since the field is still evolving and in fact most of the literature still struggles with definitions of ethnomathematics.

Nevertheless Geertz' conception of disciplines as intellectual villages and the suggestion to use convergent data provides a vantage point for the current pursuit. In this study the negotiations and debates that enrich the field are used as data to understand the 'mentalities at work'. As a 'unit' of the larger academic territory, the study on the 'intellectual village' of ethnomathematics is expected to throw light on the larger disciplinary dynamic of the period.

1.3.2 Michel Foucault-Insurrection of Subjugated Knowledges

Foucault (1980) in a brief remark calls our attention to the local character of the criticism in the second half of the twentieth century. The local character of criticism, according to him, leads to the 'insurrection of subjugated knowledges'. Subjugated knowledges refer on the one hand to those blocs of historical knowledge which were buried and disguised in the functionalist and systematising unitary theories (p.80). On the other hand subjugated knowledge is that popular, local knowledges "that have been disqualified as inadequate to their task or insufficiently elaborated: naive knowledges, located low down on the hierarchy, beneath required levels of cognition or scientificity" (p.82). The major concern of these subjugated knowledges is the 'historical knowledge of struggles' and this call for a 'multiplicity of genealogies' that helps to rediscover these struggles. A genealogical project "entertain(s) the claims to attention of local, discontinuous, disqualified, illegitimate knowledges against the claims of a unitary body of theory which would filter, hierarchies and order them in the name of some true knowledge and some arbitrary idea of what constitutes a science and its objects" (p.83).

For Foucault the major contestation of these genealogies of subjugated knowledges is with the centralising and hegemonic power of the scientific discourse, which governs statements of truth and falsity, of utility and adequacy. Thus genealogy does not aim to inscribe knowledges in the hierarchical power of scientific discourse, but attempts to "emancipate historical knowledges from that subjection, to render them, that is, capable of opposition and of struggle against the coercion of a theoretical, unitary, formal and scientific discourse" (p.85). These subjugated knowledges and their fragmented genealogies do not render themselves for unification or homogenisation under any single framework. Rather their study should explore the fundamental issue at stake-power and knowledge.

Foucault's insights into the politics of discourse underlying subjugated knowledges and their relationship with the unitary scientific theories enable us to reflect on the field of ethnomathematics as a field of contestations and negotiations for power. [7] Ethnomathematics positions itself in opposition to the hegemonic discourse of academic mathematics and seeks to challenge its assumed scientificity and rigour by showing that mathematics is a cultural expression which has myriad manifestations. An historical exploration of the power relations and their mechanisms underlying the field of ethnomathematics will throw light not only on the development of the field but also on the history of the discourse which inhibited the emergence of such a field and the later conditions which have now made the field possible.

1.3.3 Pierre Bourdieu- Specificity of Scientific Field

Bourdieu posits that power dynamics in a scientific field takes on a specific character given the specific nature of the scientific field. His exposition of the specificity of the scientific field enables us to understand the negotiations at

[7] Nevertheless, for Foucault there are sciences that escape this problematic of power and knowledge.

work in the pursuit of scientific authority. Bourdieu employs the concept of the field to understand the practice of scientific knowledge.

Field encompass the structures that orient scientific practices (p.32). There are series of structural interlocking in the field which determines the relational position of each of the points in the field. Scientific field like any other field is embedded in a struggle over the distribution of power which is symoblised in the 'monopoly of scientific authority'. Monopoly of scientific authority is defined as the scientific competence derived from both technical and social power that gives one the authority to speak and act legitimately in the field.

Bourdieu perceives scientific field as a "structural field of forces, and also a field of struggles to conserve or transform this field of forces" (p.33). As a field of forces, the scientific field is comprised of agents (field sources) whose position in the field is defined by the volume of the scientific capital they possess. The structure of the field is determined by the structure of the distribution of scientific capital. The relationship between various agents in the field generates the field and the forces that it embodies. Thus the position of an agent in the field is determined by the relationship with other agents and the field as a whole, which in turn is determined by the amount of symbolic capital one possess.

As a field of struggles, the scientific field is defined and shaped by the ongoing struggle between the agents to shape, and reshape the field in other words, to transform the existing power relations. The struggle in a scientific field is organized around the opposition between the dominant and the dominated. The dominant, due to the virtue of larger degree of concentration of capital, occupies a position that enables her to put forward a representation of science, which is presented as the 'legitimate' presentation. Bourdieu contends that these legitimate representations are always in tune with the established, 'normal' notions of science and acts as a vigil against the challenges who counter this representation with constant innovation. Though the dominant agents manoeuvre to reinforce the dominant positions and representations the relations in a field does transform. This transformation according to Bourdieu takes place through the "sudden arrival of new entrants endowed with new resources" (p.36) who 'redefines the frontiers of the field" (ibid).

Scientific field also assumes a specific character due to the special nature of the symbolic capital at stake in the field. Bourdieu defines: "Scientific capital is a particular kind of symbolic capital, a capital based on knowledge and recognition. It is a power which functions as a form of credit, presupposing the trust or belief of those who undergo it because they are disposed to give credit, belief" (p.34).

Bourdieu puts forward this theoretical schema to understand the scientific field while analyzing laboratory studies of science. He argues that laboratories are 'social microcosms' or subfield of a larger universe and any attempt to understand this microcosm shall refer to its relative position and the dynamics of struggles in the larger scientific field. "Only through an overall theory of the scientific space, which understands it as a space structured according to both generic and specific logics, is it possible truly to understand a given point in this space, whether a particular laboratory or an individual researcher" (p.33).

Thus Bourdieu conceives scientific field as a larger field with agents, or subfields occupying positions in relation to each other which are determined by the structure of the distribution of scientific capital. Within this framework, ethnomathematics is seen as a field of study that forms a microcosm in the larger universe of mathematics. A discussion of the conditions conducive for the development of the subfield will help throw light on the nature of the socio-political changes that affect the field and help to reflect on the changing structure of the distribution of scientific capital. The relationship of this (sub) field with other subfields that reflect on mathematics is explored to understand the relative position of ethnomathematics to mathematics. The inner dynamics of the field is discussed to understand how the subfield negotiates this relative position.

1.4 Statement of the Problem

This research proposes an analytical and historical review of the field of ethnomathematics and its social construction. The major goal of the research is to provide an understanding of the theoretical and social juncture of the shaping and evolution of the field. The nature of the field, its epistemological and institutional dynamics and its various implications are traced. The study derives insights from sociology of knowledge and social theory of science and situates itself at a post- colonial site marked by an academic and political rigour that aims to counter the Eurocentric hegemonic discourses of knowledge and its praxis. The aim is to understand the dynamics of this encounter as manifested in an emerging field of study, in a hope to foreground the politics of knowledge which is now visualised as an intricate network rather than in terms of a centre- periphery model.

1.5 Objectives of the Research

- To write a sociological history of the emergence of the field of ethnomathematics.
- To trace the subsequent social shaping of the field.
- To identify the disciplinary and institutional dynamics that the field embodies.
- To identify the relationship between ethnomathematics and conventional academic mathematics and mathematics education
- To locate the field of ethnomathematics in the larger politics of scientific knowledge in the postmodern condition.

1.6 Research Questions

- What is the social and theoretical juncture of the emergence of the field of ethnomathematics?
- What are the internal negotiations on the identity and nature of the field that shaped its subsequent evolution?
- What are the disciplinary influences and implications that engender the field of ethnomathematics?
- What are the institutional dynamics that shape the field of ethnomathematics?
- Which academic networks, societies and associations were established to promote research and/ or educational programmes in ethnomathematics?
- What does ethnomathematics as a cognitive or social movement offers to the disciplinary terrain of mathematics education?
- What possibilities and challenges does a globalised world offer to the field of ethnomathematics as a research programme in mathematics education with larger implications for theory of knowledge production, organisation and dissemination?

1.7 Structure of the Dissertation

This dissertation is organised into three core chapters supported by an introduction and conclusion and two appendixes. After sketching a background for the study and having laid down its major objectives in the first chapter, the dissertation proceeds with a social history of the field of ethnomathematics. Second chapter titled as ***Ethnomathematics- Social History of a Field*** traces a sociological history of the emergence of the field of ethnomathematics and its subsequent evolution which is explored through the works of four major authors in the field. Varied connotations of the term ethnomathematics are highlighted and an attempt is made to define ethnomathematics at three different levels- as a concept, as a pedagogical aide and as a field of study. It is argued that an understanding of ethnomathematics as a field is more pregnant with philosophical and political challenges to conventional academic mathematics.

The third chapter- ***The Field of Ethnomathematics*** explores the nature of the field. The transdisciplinary character of the field is discussed in detail. Emphasis is laid on the development of the field after the formation of the International Study Group on Ethnomathematics in 1985. A survey of the newsletters of ISGEm is undertaken to explore the institutional and disciplinary dynamics of the field. After tracing the evolution of the field and its nature the fourth chapter proceeds with an appraisal of the impact of the field of ethnomathematics. The chapter is titled as ***The Impact of Ethnomathematics.*** In this chapter an attempt is made to explore the potential of ethnomathematics to raise pedagogical and political questions. The relationship of ethnomathematics to academic mathematics is discussed to understand the various possible strategies for interaction between the two fields. Prospects of ethnomathematics to Third World nations and the relevance of its claims in a globalised world are discussed briefly. The concluding chapter draws from the discussions in the preceding chapters and tries to put some observations in place. An attempt is made to bring out the contradictions and confusions in the field. An appendix following the conclusion will briefly mention ethnomathematical work in India.

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Chapter 2

Ethnomathematics - The Social History of a Field

Before we enter a field, it is important to understand the nature and boundaries of the field. Definitions and explanations provided for the field implicitly mark the boundaries and scope of the field and identify its subject. This chapter is an attempt to understand the field of ethnomathematics and forms the cornerstone of this dissertation. It provides a brief background to the emergence of the concept of ethnomathematics and discusses its further development through the works of four major authors in the field. The major aim of the chapter is to undertake a genealogy of the term ethnomathematics and to trace its development into a field of study by shedding light on the negotiations that go into boundary-work in a newly emerging field.

Thomas. F. Gieryn's concept of boundary provides a vantage point for the discussion in this chapter. Gieryn defines boundary work as "the attribution of selected characteristics to the institution of science (i.e. to its practitioners, methods, stock of knowledge, values and work organization) for purposes of constructing a social boundary that distinguishes some intellectual activity as non- science" (p.405). For Gieryn science is a space that is marked and filled through negotiations over cognitive authority. He explains that "boundary work occurs as people contend for, legitimate, or challenge the cognitive authority of science and the credibility, prestige, power, and material resources that attend such a privileged position. Pragmatic demarcations of science from non-science are driven by a social interest in claiming, expanding, protecting monopolizing, usurping, denying, or restricting the cognitive authority of science" (ibid). Gieryn's understanding of boundary work provides insights into the dynamics through which an emerging field of study marks and negotiates its boundaries.

Perceiving ethnomathematics as a field by invoking Bourdieu helps to understand the field as a space of negotiations, a space which is structured through these negotiations. The notion of the field also helps to deconstruct the idea of scientific community as a unified homogenous group. Conceiving ethnomathematics as a field enables us to understand the scientific practice as a field of constant negotiation in which the scientific field is embedded.

2.1 Ethnomathematics- A Background

The theoretical and historical juncture of the entry of 'ethno' into academic discourse has already been discussed in the previous chapter. However the discourse on ethnomathematics emerged later than other ethnosciences (Gerdes 1994, D'Ambrosio 1985). This was perhaps due to the conception of mathematics as an abstract, universal science.[8] Though the socio-cultural embeddedness of mathematics was pointed out by many (Spengler 1936, Struik 1942), it was only towards the end of 1970s and the beginning of 1980s that the socio-cultural aspects of mathematics and mathematics education developed as a major perspective (Gerdes 1994). This was an outcome of several developments.

Contributions to anthropology, sociology, history, and psychology and mathematics education provided the ground for the development of the field of ethnomathematics. D'Ambrosio (1985) notes that the work of anthropologists revealed that the practices that can be called mathematical are carried out in radically different ways in various cultures. These studies challenged the universality claims of mathematics. Countering the assumption of universality of Western mathematics is the first step towards the conceptualization of ethnomathematics. Recent studies on history of mathematics also show that Western mathematics is in fact an amalgam of various cultural traditions from different parts of the world (Joseph 1991).

Gerdes (1997) discusses the authors from various disciplinary background who can be considered as precursors of some of the insights of ethnomathematics. Among such 'isolated forerunners' (ibid), R.Wilder

[8] For an elaborate discussion of this resistance, see section 3.3.3.

assumes special significance. Wilder in his address to the International Congress of Mathematicians way back in 1950 talked about the *Cultural Basis of Mathematics*. He draws upon L. White's essay *The Locus of Mathematical Reality: an Anthropological Footnote* (1947) and C. Keyser's *Mathematics as a Cultural Clue* (1932), and explains how mathematics developed into its current form and the role of socio-cultural and historical factors in its development. Wilder's later works, *Evolution of Mathematical Concepts* (1968) and *Mathematics as a Cultural System* (1981) put forward the thesis that "...each culture has its own mathematics, which evolves and dies with the culture" (Smorynski 1983 quoted in Gerdes 1997 p.333).

Gerdes also discusses the work of L. White, E. Fettweis, G. Luquet and Otto Raum. White (Gerdes 1997) held that mathematics is a 'form of behavior' and mathematical truths are both discovered and manmade. He argued that the encounter with and discovery of mathematical ideas and human mind takes place in the context of the mathematical culture in which an individual grows up. This supports Linton's (1936) idea that "mathematical genius can only carry on from the point which mathematical knowledge within his culture has already reached" (quoted in Gerdes 1997 p.332).

Another work of significance is O. Raum's, *Arithmetic in Africa* (1938) that debunks the assumption that 'Africans have no gift for arithmetic' (Gerdes p.334). Analyzing mathematics education in Africa Raum argued that until and unless education is based on indigenous culture of the people it cannot be effective (ibid). This in fact is one of the major propositions of ethnomathematics as well. Among the mathematicians whose work can be seen to anticipate idea of ethnomathematics, Shirley[9] discusses the works of Morris Kline, who tried to explore the interaction of culture and mathematics in his two seminal works-*Mathematics in Western Culture* (Kline 1953) and *Mathematics: A Cultural Approach* (Kline 1962).

[9] Shirley, L: *Ethnomathematics Looks Back and Looks Forward*, http://dg.icme11.org/document/get/327 Accessed on 24/02/11.

Among the sociological works which tried to bring out the interrelationship of mathematics and culture, Oswald Spengler's thought on 'Meaning of Numbers' in his book *The Decline of the West* (1926) can be considered as seminal. He argued that every culture has its own mathematics. "There is not, and cannot be, numbers as such. There are several number-worlds as there are several cultures' (p.59) He also suggested a distinction between mathematics embedded in cultural practice and academic mathematics when he asserted that "mathematics-meaning thereby the capacity to think practically in figures -must not be confused with the far narrower scientific mathematics, that is, the theory of numbers as developed in lectures and treatise" (p.57). However, Spengler's ideas at that time were not heeded to and so was the fate of D.J. Struik's proposal for 'sociology of mathematics'. In his 1942 essay Struik argued for sociology of mathematics that "concerns itself with the influence of forms of social organization on the origin and growth of mathematical conceptions and methods, and the role of mathematics as part of the social and economic structure of a period" (p.58). He goes on to give examples of the social relations of mathematics to prove that there is room for a sociological analysis of mathematics. David Bloor's strong programme in sociology of knowledge made a strong case for sociological analysis of the mathematics. In his *Knowledge and Social Imagery*, 1976 he explored the nature of mathematics and questioned its uniqueness as an intellectual pursuit.

Anthropological research and cultural studies on mathematical practices in different cultures, in contradistinction from conventional academic practices, paved the way for the perception of mathematics as having a cultural context. This also led to several studies regarding the evolution of the concept of mathematics (D'Ambrosio 1985). Claudia Zaslavsky's *Africa Counts: Numbers and Pattern in African Culture* (1973) threw light on the nature of mathematical thought and mathematical practices in various cultures. She explored mathematical applications in the cultural practices of African people and also analyzed the influence of various African institutions on the development of mathematics. Gay and Cole's (1967) investigation among the

Kpelle children in Liberia provided new insights on school mathematics. They argued that the difference in mathematical skills among various groups is the result of the varied life styles of these different groups. Thus they affirmed the cultural embeddedness of mathematics education.

Cognitive psychologists explored the mathematical reasoning outside the school and argued that mathematical reasoning and problem solving are cultural activities which take place in a context which is also very culturally specific (Lave 1996, Saxe 1991, Walkerdine 1997). They also stressed the importance of language in the learning of mathematics. The multicultural education debate insisted on the relevance of mathematics to the cultural background of the learner (Gibson 1984, Banks 1993). Several works on mathematics education attributed the failure of students to learn mathematics to the lack of correspondence between the school mathematics and the learner's cultural background (Bishop 1999).

Apart from these contributions in various disciplines there were other social and political factors that set the ground for the emergence of the concept of ethnomathematics. The Civil Rights movements in United States in the 1960s shifted attention to the Eurocentric bias of the curriculum. Zaslavsky (1994) attributes her interest in African mathematics to the Civil Rights Movements. Gerdes (1997) notes that the debate regarding the involvement of mathematicians and mathematical research in the Vietnam War also led to the reflections on the socio-cultural bases and implications of mathematics.

The 1970s and 1980s saw a growing resistance among the teachers and researchers on mathematics education in developing countries against the Eurocentric biases in the mathematics curriculum that was transplanted from the highly industrialized countries to the Third World (Gerdes 1997, Shirley).[10] Without any appeal to the cultural background of the learner this curriculum was racist in its overtones and asserted the cultural hegemony of Europe. In an attempt to recover their lost heritage and achievements and

[10] Shirley, L: *Ethnomathematics Looks Back and Looks Forward*, http://dg.icme11.org/document/get/327 Accessed on 24/02/11.

emphasize their independence, newly emerging nations of the Third World, adopted a policy to develop culturally specific curricula that were relevant for their goals and aspirations. It was stressed that beyond the "*imported school mathematics* there also existed and continues to exist other mathematics" (Gerdes p.357). This development highlighted a conception of mathematics different from school mathematics or the conventional academic mathematics.

2.2 Provisional Concepts

Reflecting on various dimensions of mathematics scholars proposed various concepts that underpinned the idea of ethnomathematics. But the term ethnomathematics acquired currency after the presidential address of Ubiratan D'Ambrosio during the Fifth International Congress on Mathematical Education (ICME), 1984. Since then the provisional concepts related to ethnomathematics were gradually assimilated under the more general rubric of *ethnomathematics* (Gerdes 1994).

Gerdes (1994) offers a very brief description of these terms and concepts used by different authors. Gay and Cole (1967) used the term *indigenous mathematics* in their study on the Kpelle Children in Liberia while pointing out that the instruction of children in their Western oriented schools did not have any relevance or meaning within their cultures. They proposed a certain educational scheme that employed indigenous mathematics as its starting point. Claudia Zaslavsky in her *Africa Counts: Numbers and Pattern in African Culture,* 1973 uses the term *African socio-mathematics* referring to the mathematical practices of the people in Africa.

D'Ambrosio (1982) in his early works used the term *spontaneous mathematics* to suggest that each human being and each cultural group develops certain mathematical methods spontaneously. *Oppressed mathematics* was a term used by Gerdes (1982) suggesting that there exist mathematical elements in the daily life of the population that are not recognized as mathematics by the dominant mathematics tradition. While Gerdes' oppressed mathematics talked about the mathematics in Third World countries during the colonial occupation, *non-standard mathematics*[11] (Carraher et. al. 1982, Gerdes 1982, 1985, Harris 1987) was a term that referred to the mathematics of daily life which is developed in every culture around the world but is different from the established, academic and school mathematics. Gerdes (1982, 1985) also proposed the term *hidden* or *frozen mathematics* suggesting that the mathematical knowledge of the formerly colonized people which is lost lies frozen or hidden in old techniques like basket making and that it can be reconstructed. While discussing the importance of culture for mathematics education, Mellin-Olsen (1986) used the term *folk mathematics* to denote the mathematics that develops in the working activity of the people. According to them this folk mathematics should be used as the starting point in the teaching of mathematics. Gerdes (1994) points out that apart from these; concepts like *oral mathematics* (Carraher et.al. 1982, Kane 1987) were also used in different contexts.

[11] The term non-standard mathematics also refers to a recent subfield in academic mathematics that formulates analysis using a rigorous notion of an infinitesimal number.

Table.1 Provisional Concepts

Concepts	Definitions	Proponents
Indigenous mathematics	Mathematics that is indigenous to a community	Gay and Cole 1967
Sociomathematics (of Africa)	Mathematical applications in the life of African people	Zaslavsky, 1973
Informal Mathematics	Mathematics that is transmitted and that one learns outside the formal system of education.	Posner, 1982
Spontaneous mathematics	Mathematics that each human being and cultural group develop spontaneously a part of solving everyday challenges	D'Ambrosio, 1982
Oppressed mathematics	Mathematical elements in daily life of the people in class societies especially in Third world countries that are not recognised as mathematics by the dominant ideology and are thus oppressed.	Gerdes, 1982
Non-standard mathematics	Mathematics of daily life which is developed in every culture around the world but is different from the established, academic and school mathematics.	Carraher et.al. 1982 Gerdes, 1982, 1985 Harris, 1987
Hidden or frozen mathematics	Mathematical knowledge of the formerly colonized people which is lost and lies hidden or frozen in old techniques like basket making.	Gerdes 1982,1985
Folk mathematics	Mathematics that develop in the working activity of people	Mellin- Olsen, 1986
Oral mathematics	Mathematics that exists in all human societies and that is transmitted orally from one generation to another.	Carraher et.al 1982 Kane 1987

A growing awareness of the social and cultural background of mathematics has had institutional repercussions. Gerdes (1997) points out that conference on mathematics held during this period provided space for the discussion of social and cultural aspects of mathematics and mathematical education. One of the first such instances was the discussion on the "Objectives and Goals of Mathematics Education" at the Third International Congress of Mathematics Education, which took place in Karlsruhe, Germany in 1976 (ibid). Ubiratan D'Ambrosio sees this as the first moment in the recognition of the idea of ethnomathematics.[12] At Karlsruhe, Ambrosio proposed to include a discussion of the nature of mathematical knowledge in the curriculum with emphasis on its historical, philosophical and cognitive aspects. He also insisted that there are different ways of doing mathematics (ibid). These thoughts were put together in a booklet produced by the State University of Campinas (UNICAMP) in 1976 entitled *Overall Goals and Objectives for Mathematics Education*. Ambrosio had another platform for his ideas at the annual meeting of the American Association for the Advancement of Science, in 1978 at Washington D.C. At the session on 'Native American Science' Ambrosio spoke about the 'scientific and the mathematical knowledge and practice of the Native American people'. He indeed used the term ethnosciences and ethnomathematics. But at this meeting, it failed to make an impact (ibid). In 1975, D'Ambrosio founded a Master's Programme in Teaching Sciences and Mathematics at the State University of Campinas (UNICAMP). D'Ambrosio's ideas on ethnomathematics were largely influenced by his experiments and experience with this program (Francois and Kerkhove 2010).

However, the year 1978 was a fruitful year for the development of ethnomathematics (ibid). The conference on 'Developing Mathematics in Third World Countries (Khartoum, Sudan, 1978) the workshop on 'Mathematics and the Real World' at the Roskilde University in Denmark, the session on Mathematics and Society at the International Congress of Mathematicians at Helsinki, Finland in the same year provided a fruitful

[12] D'Ambrosio *A Reflection on Ethnomathematics: Why Teach Mathematics?*, **http://vello.sites.uol.com.br/why.htm,** accessed on 15/12/2010.

ground for the emergence of ethnomathematics as a field. This trend continued in 1981 with the symposium on Mathematics in the Community (Huaraz, Peru) and also in 1982 with the Caribbean Conference on Mathematics for the Benefit of the People at Paramaribo, Surinam (Gerdes 1997), culminating with the Fifth International Congress of Mathematics Education (ICME V) in Adelaide where D'Ambrosio gave the opening plenary lecture on the socio-cultural bases for mathematics education. This turned out to be a milestone in the history of the concept and field of ethnomathematics. This was followed by a series of publications by D'Ambrosio and the term gradually gained currency, and D'Ambrosio came to be called as the 'intellectual father of ethnomathematics' (Gerdes 1997).[13]

2.3 The Concept of Ethnomathematics

A monochromatic definition of the concept of ethnomathematics is difficult precisely because it is an emerging field and also due to its transdisciplinary nature. The concept has acquired varied references depending on the context and intentions of the authors. It has been used in varied connotation-as body of knowledge, as a set of practices, as a process in the making of knowledge, as an approach in mathematics education, as a research programme etc. These shifts in meaning can also be perceived in the works of a particular author over a period of time. The changing meaning of the concept leads to a difficulty in the exposition of its philosophical premises and generates a variety of interpretations regarding its role in mathematics education. Researchers have tried to arrive at a comprehensive definition for ethnomathematics that will resolve these perplexities (Barton 1994, 1996). This chapter does not purport to propose a comprehensive definition or explanation for the concept. The

[13] Though Gerdes trace the development of ethnomathematics in its initial years he does not explain the social and academic situation of the time that proved fruitful for the reception of the field of ethnomathematics. The previous chapter in this dissertation provides a hint in this regard.

major aim here is to shed light on the various connotations of the term ethnomathematics and to understand them as negotiations in a field.

The term ethnomathematics was in use before D'Ambrosio's 1984 lecture at Adelaide. Otto Raum used the term 'ethno-math' on the analogy of ethno-music, ethno-semantic etc, in a review of Zaslavsky's book, Africa *Counts,* which was published in 1976 in *African Studies.* Wilber Mellema mentions that he used the term in 1967 and gave a talk in 1971 where he employed it. Ascher in a letter published in ISGEm Newsletter in 1986, discusses her use of the term ethnomathematics in an article which she wrote before she was aware of the use of the term by D'Ambrosio. William David Barton states that 'before the ICME lecture by D'Ambrosio the term ethnomathematics referred to the anthropological field of the study of the mystic role of number in different cultures, or to mathematical techniques in the field of ethnology, for example using mathematical analysis to distinguish language structure" (1994 p.22). D'Ambrosio acknowledges this but says that he was not aware of use of the term before and gives his own etymological explanation of the term.[14]

The cultural character of mathematical activity has been explored in several works and several concepts including the term ethnomathematics were proposed. However these studies were largely fragmentary and were defined and restricted by the disciplinary contexts in which they developed. The development of ethnomathematics as a concept provided a space for unifying these fragmentary studies. One of the most important points of departure in this process was D'Ambrosio' 1984 Adelaide lecture, in which he proposed his concept of ethnomathematics. The fact that it was put forward in the International Congress on Mathematical Education gave widest possible visibility to the concept which was unlikely for other concepts.[15] This visibility provided a scope for people with similar ideas to come together and the development of the field was marked by the formation of the International

[14] D'Ambrosio *A Reflection on Ethnomathematics: Why Teach Mathematics?*, http://vello.sites.uol.com.br/why.htm, accessed on 15/12/2010.
[15] See section3.4 for an elaborate discussion on the institutional dynamics that facilitated the development of the field of ethnomathematics.

Study Group on Ethnomathematics in the following year. On the basis of this many scholars in the field (Gerdes 1997, Shirley[16]) consider the plenary lecture delivered by D'Ambrosio at the ICME-1984 as the inauguration of the field. This study also takes D'Ambrosio's lecture as the inauguration of the field of ethnomathematics and focuses on the works that followed it.

An exhaustive review of literature of the field will be out of the scope of this dissertation. Hence for the sake of brevity the discussion is structured around the works of four major authors in the field-Ubiratan D'Ambrosio, Marcia Ascher, Paulus Gerdes and Bill Barton. D'Ambrosio and Ascher are considered pioneers of the field. Many authors derive the understanding of the concept of ethnomathematics from them. D'Ambrosio's work provides a sociological and historical perspective on ethnomathematics at the same time highlighting its pedagogical implications. Ascher like D'Ambrosio is a mathematician and her work impinges on the definition and nature of mathematics that is linked up with the need to intervene in mathematics education. Paulus Gerdes also works on mathematics teaching and learning but his works highlight the political potential of ethnomathematics, by arguing for defreezing the mathematics that lies frozen as an impact of the colonial rule in the Third World countries, whereas Barton's work is important for understanding the philosophical stance of ethnomathematics. Thus an analysis of the work of these four authors will enable us to understand the various dimension of the concept of ethnomathematics. Nevertheless, this is not to suggest any sort of ownership of the field to these authors, nor is the discussion confined to them alone. Several other works shall be referred to in order to highlight the major points of discussion which follows in the remaining chapters.

[16] Shirley, L: *Ethnomathematics Looks Back and Looks Forward*, http://dg.icme11.org/document/get/327 Accessed on 24/02/11.

2.4 Ubiratan D' Ambrosio

2.4.1 The Field of Ethnomathematics

Any discussion of ethnomathematics begins with an acknowledgment of the contributions of Ubiratan D'Ambrosio to the emergence and development of the field. He is considered the intellectual father of the field (Gerdes 1997) and for some he is the spokesperson of ethnomathematics.[17] His conception of ethnomathematics calls for a broader understanding of mathematics, while as a research program he emphasizes the implications of ethnomathematics for history and philosophy of mathematics and science. His works are also explicit about the pedagogical dimension of ethnomathematics and these concerns relate to the larger argument about the process of knowledge production and distribution. A Freirian perspective can also be discerned in D'Ambrosio's works, when he argues for a new model of schooling system that is based on human values and is imperative for a democratic society.

For D' Ambrosio, the term ethnomathematics is a combination of three terms- *ethno, mathema* and *techne.* Mathema is the intellectual venture of explaining. It is the result of a challenge and generates ways of facing these challenges (D' Ambrosio 1994 p.37). Using mathematical ideas to invent ways of dealing with challenges, results in broadening the scope of such technical ways. According to D' Ambrosio, such ideas are more than mere technique and he employs the term 'tics' derived from Greek term *techne* that stands for both technique and art. Finally, both mathema and techne are embedded in culture, hence the prefix ethno, and the term ethnomathematics (ibid). Thus an etymological definition of the term ethnomathematics would be "the art or technique (tics) of explaining, understanding, coping, with (mathema) the socio-cultural and natural (ethno) environment" (1990 p.22). This definition is an exhaustive one in the sense that it also hints to the larger process of knowledge production, thereby widening the scope of ethnomathematics. According to D'Ambrosio the concept of 'ethno' derives from a "concept of

[17] Shirley, L: *Ethnomathematics Looks Back and Looks Forward,* http://dg.icme11.org/document/get/327 Accessed on 24/02/11.

culture as a result of a hierarchization of behavior, from individual behavior through social behavior to cultural behavior (1985 p.45). This on the other hand depends on a model of individual behavior in which reality, individual and action exists in a cyclic relationship. The information gathered from the environment produces stimuli in the individual. These stimuli become strategies through reification which result in action. This action in turn impacts reality by adding to it, and the process provides in a cyclical manner. The dynamics of this interaction, mediated by communication and resulting codification and symbolization, produces structured knowledge that eventually becomes a discipline. For D'Ambrosio "this ceaseless cycle is the basis for the theoretical framework upon which we base our ethnomathematics concept" (ibid p.46). He explains the process of knowledge production with the help of this holistic model which pays attention to the cognitive as well as social and historical aspects of the process. Expositing this framework further, he poses three questions pertaining to the process of building scientific theories.

1) "How are and how practices and solutions of problems developed into method?
2) How are the methods developed into theories?
3) How are the theories developed into scientific invention?" (ibid).

Within this framework he defines ethnomathematics as the practices that do not reach the level of formalization and theorization. Because history, especially the history of science is concerned narrowly on the structured body of knowledge, ethnomathematics falls outside the purview and is denied any status as knowledge. It is rather recognized as a set of ad hoc practice. Hence, the major aim of the programme of ethnomathematics "is to identify within ethnomathematics a structured body of knowledge" (ibid p.47). Thus ethnomathematics calls for a broader conception of mathematics, of history and of knowledge at large.

D'Ambrosio (1994) argues that the definition of mathematics has to be broadened beyond problem-solving practices - the essence of human life is the inseparable relationship of transcendence and survival. Hence to separate acts of survival from acts of transcendence is unwarranted. Similarly, mathematical ideas cannot be separated from aesthetics nor can it be thought of as an abstract entity devoid of any context. The suppression of context and quantification of values for comparison delinks mathematics from life and culture. Thus ethnomathematics presumes an extended notion of mathematics. In that sense, ethnomathematics can be defined as a "corpora of knowledge derived from quantitative and qualitative practices such as counting, weighing and measuring sorting and classifying" (p.3). In other words "it is the mathematics which is practiced among identifiable cultural groups such as national tribal societies, labour groups, children of a certain age bracket, professional classes and so on" (1985 p.45). The identity of ethnomathematics "depends largely on focuses of interests, on motivation and on certain codes and jargons which do not belong to the realm of academic mathematics" (ibid).

2.4.2 The Ethno-Ethnic Distinction

To explain his definition of ethnomathematics further, D'Ambrosio distinguishes between ethnomathematics and ethnic mathematics. Ethnic mathematics refers to the ethnographic approach adopted mainly by anthropologists and psychologists while studying other cultures. Such studies generate rich sources of information for ethnomathematics, but differ from ethnomathematics in terms of intention and nature of investigation. A paternalistic curiosity is prevalent in majority of these 'ethnic' works and they can easily lead to a folkloristic view other cultures, thereby reinforcing the Eurocentric conception of mathematical knowledge (D'Ambrosio 1997 p.14). Moreover, such ethnographic studies fall short of explaining the complex form and structures of knowledge underlying cultural practices in different cultures.

Whereas, ethnomathematics is a larger programme of understanding the generation, organization and diffusion of knowledge and thus has immense implications for history and pedagogy of science and mathematics. In other words, it not only encourages the recognition of other ways of thinking, but also encourages broader reflection about the nature of (mathematical) thought, from the cognitive, historical, social and pedagogical points of view (2001).

In his works *Ethnomathematics-Link between Tradition and Modernity* (2001) D'Ambrosio discusses various aspects of the ethnomathematics programme. The conceptual dimension refers basically to what has been offered as the etymological definition of ethnomathematics. It refers to those aspects of ethnomathematics, that reflect on how accumulation of knowledge both artifacts and mentifacts 'compatiblilize' behavior and how this constitutes the culture of the group. The historical significance of ethnomathematics is inferred from the fact that the history of science is undergoing a renaissance presently. The earlier emphasis on quantitative reasoning is gradually giving way for an intense search for qualitative reasoning[18] as well as the earlier approach informed by rigidly defined disciplinary boundaries is being replaced by broader approaches informed by insights from various disciplines. Ethnomathematics-as an approach that argues for a holistic perspective with a predominant qualitative character thus becomes "one of the manifestations of this new renaissance" (p.19).

D' Ambrosio explains that Homosapiens posses the capacity to harness the knowledge of previous generations. This result in a cumulative process of cultural production through which knowledge production takes place and in this process, communication systems play a vital part. This cumulative knowledge is shared by the group in which it developed and results in a compatibilization of behavior of the group. Thus culture can be defined "as a set of shared knowledge and compatibilized behavior" (p.22). Thus the unique

[18] D'Ambrosio argues that the interest in artificial intelligence is an instance of this growing trend based on qualitative reasoning. He sees this as a welcome sign for ethnomathematics because ethnomathematics is also based on this search for qualitative explanation (2001, p.19).

cognate ability of Homo sapiens results in a shared culture in which they use similar intellectual and material instruments to meet the challenges of everyday life. The corpus of such knowledge, especially of a mathematical nature is called ethnomathematics. Hence the cognitive dimension of ethnomathematics presumes that different environments produce different ethnomathematics.

The ethnomathematics programme has obvious implications for epistemology by questioning the dichotomy of the empirical and the theoretical and this point to the epistemological dimension of the program. The current framework in history of science explains the process of explanation of knowledge in a reductionist manner for it focuses only on "knowledge already established, according to the accepted paradigm of time and of moment" (p.26). This framework is too narrow for understanding non-Western forms of knowledge that develop through an integral and dynamic cycle involving knowledge and practice. Such an intricately interacting system cannot be studied by fragmentation of various phases of the cycle. It calls for a holistic approach and hence the epistemological dimension of ethnomathematics becomes all the more important.

Ethnomathematics is explicitly political in its claim for restoring the status of knowledge to those practices in other cultures which are outside the purview of dominant knowledge systems. This acquires added significance in the erstwhile colonized societies, where their knowledge traditions were deliberately tramped upon during the process of colonization. Destroying the native's corpora of knowledge and experience was the major strategy of colonization, regaining and reassuring it shall be the forefront strategy for decolonization. But D'Ambrosio clarifies that this restoration of dignity does not mean rejecting the colonial knowledge but reinforcing one's own roots through a process of synthesis.[19]

[19] However D'Ambrosio fails to explain the nature of this synthesis and the nature of the product of such a synthesis. The question of how does this synthesis process navigate the

This leads us to the educational dimension of ethnomathematics, for ethnomathematics serves as a pedagogical strategy for cultural decolonization. Again incorporating ethnomathematics into the curriculum does not mean replacing academic mathematics. On the other hand it calls for an assimilation of two systems of knowledge with an aim of "perfecting them, incorporating values of humanity, synthesized into an ethics of respect, solidarity and co-operation" (2001 p.31). As ethnomathematics privileges qualitative reasoning and rejects the rigid distinction between theory and practice, it encourages a mathematics education that is active and critical. The emphasis on the context also makes it a useful aid in multicultural education. In a technology driven society, the importance for an active mathematics education cannot be undermined. Hence, ethnomathematics assumes importance as a pedagogical strategy.

Given its various dimensions, ethnomathematics can be defined as a "research programme in history and epistemology of mathematics with pedagogical implications".[20] The major thrust of D'Ambrosio' conception of ethnomathematics is his broader perspective of knowledge. For him, ethnomathematics is not only a programme in mathematics or mathematics education but is a larger programme concerned with the evolution of knowledge impinging upon the fate of humanity as a whole. This is explicitly expressing in his recent writings in which he links ethnomathematics to the questions of democracy, justice and peace.

D'Ambrosio (1990) argues that mathematics is well integrated into the technological, industrial, military economic and political systems and hence cannot be separated from the problems and crisis in each of these spheres; which impact on the human beings capability for survival with dignity. He visualises an important role for mathematics and mathematicians educators in the evolution of mankind. Contemporary society owes a lot to mathematics,

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power dynamics which underlies the encounter of two different knowledge traditions is left unanswered.

[20] D'Ambrosio: *A Reflection on Ethnomathematics: Why Teach Mathematics?*, http://vello.sites.uol.com.br/why.htm, accessed on 15/12/2010.

science and technology for its successful sustenance. The current discourse on mathematics, science and technology, is layered over a political discourse which tries to normalize the otherwise deleterious hierarchy among people, societies and systems (ibid).

The conception of mathematics as a monolithic category has to be abandoned. Understanding mathematics as a dynamic notion which is in constant interaction with the natural and cultural environment is a step forward for a just and dignified life for everyone on this planet. This march towards humanity D'Ambrosio says shall begin from schools, for schools are meant to enhance creativity or spontaneity in the students. Instead of building a strong citizenry who have equal privileges and functions in the state, schooling systems serve to filter the students into various categories defined by their abilities. Mathematics plays an important role in this categorization and hierarchization. Schooling systems perpetuate symbolic violence by denigrating the fund of knowledge and experience that the learner brings to school and by celebrating conventional academic knowledge, which is hegemonic, in other ways too. D' Ambrosio quotes the Universal Declaration of Human Rights, 1948 to emphasize that "it is an undeniable right of every human being to share all cultural and natural goods needed to his/her material survival and intellectual enhancement".[21] Thus by asserting a more active role for mathematics in democratic societies, D' Ambrosio links ethnomathematics to peace in its various dimension-interior, social environmental and of course diplomatic.

D'Ambrosio' conception of ethnomathematics can be seen as drifting towards a 'research field' from a concept that denotes the cultural practice of a particular cultural group. He defines ethnomathematics as a process in knowledge production and also it as a program to understand the process of

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[21] D'Ambrosio: *Ethnomathematics A Response to the Changing Role of Mathematics in Society*
, http://ebookbrowse.com/ubiratan-d-ambrosio-ethnomathematics-a-response-doc-d29459442 Accessed on 20/02/2011.

knowledge production. These varied connotations of ethnomathematics can be understood as arising from an attempt to define an emerging field which in turn is embedded in a larger politics of scientific knowledge that determines the evolution of newer perspectives and fields.

2.5 Paulus Gerdes

For Gerdes, ethnomathematics as a field of research lies at the intersection of cultural anthropology and mathematics with direct implications for education. Most of his work has been an exploration of the mathematics embedded in culture and describes various strategies to incorporate these mathematical ideas into the curriculum. Gerdes's works like D'Ambrosio' are explicitly political and he emphasizes on the processes of decolonization in Third World countries. It would be worthwhile to begin the discussion of Gerdes' contribution to ethnomathematics with his studies on the politics of mathematics education.

According to Gerdes, colonization has devastated the native culture in all possible ways and created a culture in which the natives have become ashamed of themselves and their culture. This devaluation of culture was affected in two ways. The most natural and obvious was through institutions of education. The other way of doing it was more subtle and had a longer impact. It was the practice of 'folklorizing' the native culture: "...it's reduction to more or less picturesque habits and customs, to impose in their place the value of colonialism" (Gerdes 1988 p.139).

Local scientific and mathematical knowledge was devalued in similar ways. Science was presented as an 'exclusively white man's creation and ability' and the mathematical capacities of the colonized people were negated or reduced to rote memorization. The mathematical tradition of the colonized people was ignored or despised and Western mathematics imposed on them as being more rational and useful.

Gerdes (1981) writes:

> "The teaching of mathematics played an important role in diffusing the values of the ruling class, such as private property, the exploitation of man by man, the plundering of the colonised territories, and contempt for women. The mathematics curricula were the ones used in Portugal, during the 1960s 'enriched' by a formal introduction of the vocabulary of set theory, without, however, using it to understand mathematics. Mathematics seemed to be identified with written arithmetic. Very little attention was given to mental arithmetic and geometry" (p.457).

The process of that commended in the 1950s in the Third World now appears not only as a political process, but also an economic, social and cultural process. A major part of this process of 'cultural rebirth' is the reconstruction of mathematical ideas that lie frozen or dormant or hidden away as a consequence of colonization. These mathematical ideas are embedded in cultural practices of the community like weaving, tapestry, storytelling, pottery making etc. and has to be thawed. To uncover this mathematics will amount to giving back to people, their culture and tradition which will in turn induce a self confidence in them about themselves and their people and this confidence is an essential ingredient of any anti-colonial/decolonizing movement. Mathematics education is a powerful site for this process (Gerdes 1985).

Gerdes (1986) argues for a mathematics education that is emancipatory. *Emancipatory mathematics* education refers to a situation where everyone masters mathematics and is capable of thinking mathematically, which can be utilized to the benefit of society as a whole. Mathematics will no longer be considered an alien subject or an elite pursuit. This emancipatory education requires a massification and democratization of education and calls for awareness among the people about their mathematical potentials and a self confidence about their ability to understand explore and utilize mathematics for their needs. One way of achieving this awareness and confidence is the use of problematizing reality approach in classrooms. This approach requires that real problems are brought into mathematics rather than discussing imaginary, abstract situations. This helps in political, physical as well as economic awareness and leads "to consciousness, to awareness of the relevance of mathematics as a tool to understand and transform reality" (Gerdes 1985 p16). It also motivates the students and introduces them to the power and potentials of mathematical methods in everyday life which in turn requires developing specific strategies working towards cultural, social and individual emancipation.

Cultural strategies include developing a cultural history of mathematics, which shows not only how, but also why and for whom, mathematics developed in different societies in distinct epochs (ibid). Such a history will challenge the Eurocentric history of mathematics as well as encourage an understanding among the people that every culture produces mathematics and is capable of doing so. These social strategies as suggested by Gerdes help to reinforce the confidence induced through cultural strategies. Social strategies will involve debunking the myth of the relationship between gender and mathematics, social class and mathematics, and any other similar prejudices that makes mathematics the prerogative of a select talented few. The realization that everyone is capable of doing and developing mathematics, despite their social background is a necessary condition for emancipatory mathematics education. These cultural and social strategies have to be supported by individual strategies or more precisely *individual-collective strategies*. This requires people as individuals and as groups, to reflect on the process of mathematics, i.e. reflecting on the errors and on the process of concept building. Situations have to be invented where people learn to discover, by collectively reflecting on problems and challenges of a mathematical nature. Apart from creating confidence among the students about their creative powers, this way of doing mathematics will also help to 'understand the non-tautological nature of mathematical knowledge' (ibid p.20).

These strategies according to Gerdes are meant for both teacher training and for school education of mathematics. However, we see an emphasis on teacher training. For Gerdes, 'cultural conscientization' of teachers assumes greater importance.[22] The teacher's role is of prime importance in any curriculum reform (1981). Moreover, developing awareness about the importance of hidden mathematics and inducing a confidence to explore and develop it in teachers is a precondition for stimulating students.

Gerdes makes a strong case for the inclusion of ethnomathematics into school mathematics curriculum. He also elaborates on how to identify and develop the mathematical ideas embedded in cultural practice, so that they can be included in the curriculum. Some of the mathematical ideas like the traditional counting methods are easily recognizable. Some other ideas can be explored through oral history. For ideas like hidden geometrical thinking he alludes to activities like weaving or basket making, Gerdes puts forward a method to unfreeze them. He suggests beginning through the exploration of the reasons behind the particular form and shaping of various objects and then to use similar production techniques to experiment with a new shape for that same object. Gerdes argues that through this exercise it was possible to prove that the "form of these objects is almost never arbitrary, but generally represents many practical advantages, and is, quite a lot of the times, the only possible or the optimal solution of a production problem" (Gerdes 1988 p.140). Thus Gerdes concludes that the artisan who developed that particular production technique and that particular form was involved in thinking and doing mathematics.

There are several ways to uncover hidden mathematics that can be developed and incorporated into the curriculum. This way of doing ethnomathematical research helps not only to revive a traditional mathematical idea but also helps

[22] Gerdes borrows the idea of cultural conscientization from Paulo Freire (1970). Freire defines cultural conscientization as "the process in which men, not as recipients, but as knowing subjects, achieve a deepening awareness both of socio-cultural reality which shapes their lives and their capacity to transform that reality" (p. 57).

to dispel socio-cultural and psychological alienation which otherwise besets mathematics education.

As the ongoing discussion shows, Gerdes like D' Ambrosio and Ascher, does not argue for a replacement of school mathematics by ethnomathematics. His emphasis is on the incorporation of mathematical ideas into the curriculum, which will help to promote multicultural education and stimulate interdisciplinarity. With that in mind he proposed the incorporation of mathematical ideas from different communities and he hopes that it will induce a confidence in mathematics and 'facilitates the assimilation of world mathematics'.[23] He also questions the underrepresentation of various cultural groups in the history of mathematics. His work on the geometrical patterns in the African practices of basket making, weaving, body painting etc. serves to uncover and reconstruct mathematics in activities that are primarily performed by women and tribals (1997, 1988, 1985). He argues that analyzing the underrepresentation of various cultural groups in the mainstream history and philosophy of mathematics provides explicit evidence for the ideological prejudice implicit in these bodies of knowledge. Ethnomathematics challenges all these assumptions by asking "whose mathematics is the object of philosophical analysis?"[24]

A brief review of various empirical studies undertaken by Gerdes show that he views ethnomathematics research as primarily as a way of exploring and incorporating into the curriculum, the mathematical tradition of communities like women and tribes who are otherwise thought of as incapable of doing mathematics. Gerdes follows the idea of ethnomathematics put forward by D'Ambrosio and argues that mathematics is not neutral, but embroiled in a complex mesh of socio-economic politics. Gerdes' major thrust is on this

[23] Gerdes borrows 'world mathematics' from Hogbe-Nlend, (1985). It is defined as the union of all ethnomathematics (Gerdes 1988 p3).

[24] Gerdes: *Ethnomathematics as a New Research Field, Illustrated by Studies of Mathematical Ideas in African History*
http://iep.univalle.edu.co/~gem-uv/iascud/libro/libro_pdf/Ethnomathematics%20as%20a%20new%20research.pdf
Accessed on 20/02/11.

political aspect of mathematics and mathematics education and for him ethnomathematics is a paradigm to expound it. He distinguishes the ethnomathematical paradigm from the perspective of ethno-sciences employed by ethnographers and 19^{th} century anthropologists. He argues that the concept of ethno-sciences used by them was very limited in scope and ideologically laden, that hierarchizes the sciences by the prefix 'ethno' whereas ethnomathematics tries to break away from this ideological weightage.[25] According to Gerdes, there are three basic characteristics of the ethnomathematical paradigm-a broader concept of mathematics, emphasis on the socio-cultural and historical aspects of mathematics and mathematics education and a conception of mathematics as a pan- human cultural activity.[26]

In Gerdes' empirical works we can identify various connotations of ethnomathematics. While referring to the hidden[27] mathematics in cultural practices, Gerdes uses 'ethnomathematics' to denote a body of knowledge embedded in cultural practices. When referring to the exploration of hidden mathematics ethnomathematics invokes a paradigm and methodology that provides tools for investigation in to cultural practices. Gerdes reflects that the definition of ethnomathematics as the mathematics of a certain such culture would imply that western mathematics is also an example of ethnomathematics. Hence, given the extensive range of theoretical and methodological propositions put forward by ethnomathematics, he prefers to view ethnomathematics as a research field. As a research field, Gerdes defines ethnomathematics as the "cultural anthropology of mathematics and mathematical education" (1997 p.343). He also finds ethnomathematics as close to sociology of mathematics when it is defined as a 'study of mathematics (or mathematical ideas) in its (their) relationship to the whole of

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[25] It is a point if contestation if ethnomathematics has actually achieved this ideological dissociation. Even within the field of ethnomathematics it is debated and proposals were put forward for new names for the field (see section 3.4) also see the reflections on ethno/alternative in the conclusion.

[26] All three can be accommodated within the paradigm of science as a cultural universal. What is special about ethno-science or ethnomathematics is left unexplained in the literature (ibid).

[27] Gerdes do not distinguish between hidden mathematics and frozen mathematics. He uses both the terms to denote the mathematics lying dormant in cultural practices.

cultural and social life (ibid). Gerdes observes that the high level of motivation of the researchers in the field of ethnomathematics also qualifies it as a movement (ibid). He points out various characteristic of ethnomathematics as a movement summarized below.

- Use of a broad concept of mathematics.
- Emphasis on the socio-cultural factors on education and development of mathematics.
- Mathematics is considered as a pan-human activity as well as a cultural product which has history that is in no way a history.
- Emphasis on the impotency and intrinsic alienation of the transplanted, imported curriculum in third world countries.
- As a movement ethnomathematics attempts to realize and reconstruct the cultural element of the formerly colonized people.
- Explores ways of incorporating mathematical traditions in school curriculum.
- Explores other cultural elements and ways of doing and elaborating mathematics in the classroom and
- Favors a critical mathematics education.

Gerdes, in his more recent works also uses the term ethnomathematicology on the lines of the term ethnomusicology.[28] He argues for an intercultural intelligibility of mathematical thinking, and defines ethnomathematics "as the field of inquiry that studies mathematical ideas in their historical-cultural contexts" (ibid).

[28] Gerdes, *Ethnomathematics as a New Research Field, Illustrated by Studies of Mathematical Ideas in African History* http://iep.univalle.edu.co/~gem-uv/iascud/libro/libro_pdf/Ethnomathematics%20as%20a%20new%20research.pdf Accessed on 20/02/11

2.6 Marcia Ascher

Ascher's work and D'Ambrosio's work converge on several points. Especially, the insistence on the relationship between culture and mathematics, a broader conception of mathematics and their views regarding the relationship between ethnomathematics and school mathematics strike similar cords. Marcia Ascher a mathematician was initiated into ethnomathematics through her study of the *Code of Quipu* (1981) which she undertook with Robert Ascher, an anthropologist. This combination of anthropology and mathematics results in rich discussion of the several issues which guide Ascher in her subsequent endeavors also.

In her earlier works, with Robert Ascher, Marcia Ascher defines ethnomathematics as the 'study of mathematical ideas of non-literate people' (1997 p 25). She uses the term non-literate to counter and overcome the prejudices associated with the term 'primitive' which was hitherto used in anthropological literature to refer to the non-Western 'other'. She argues that the usage of 'primitive' places people and their ideas at the beginning of a chronologically organized discussion inspired by the classical evolutionist theory. Such a perspective result in these societies being viewed as inferior because they belong to lower stages of social evolution and Western civilization because of its higher position takes up the task of defining the standards. In order to avoid these socio-political prejudices, Ascher and Ascher use the term 'non-literate' instead of 'primitive'. In her later works Ascher realizes that the term non-literate is also too narrow and limited and tends to exclude a large group of people (1991). She attempts a much broader term and defines ethnomathematics as an endeavor that includes the 'study of the mathematical ideas of traditional people' (ibid). In other words, it is the study of "the mathematical ideas of people who have generally been excluded from discussions of mathematics" (1991 p.1).

As has already been pointed out, one of the major foci of Asher's work is her emphasis on the relationship between culture and mathematics. She defines culture in a broad sense to include shared 'language, place, traditions and ways of organizing, interpreting, conceptualizing and giving meaning to the physical and social world' (ibid). She further explains that because of the spread of a few dominant cultures across the world, there is no culture which is 'pure' or which has not been influenced by any other culture. However, the ideas that evolve in these various cultures may differ because the ideas are intrinsically related to the social and physical habitat of the people. Even similar ideas may have different expressions in different cultures. This again derives from the social organization of the community which generates the ideas. Different cultures may emphasize different ideas according to the needs of their survival and transcendence. To put it in her words, "particular orders develop within cultural contexts and their form and content will be necessarily expressive of the content in which they arise" (1997 p.26). Hence, Ascher argues that since traditional non-literate societies do not have a group of professionals called mathematicians it is difficult to find mathematics in its explicit form. In other words, the category of ideas we label mathematical may exist, but they are not labeled so. The mathematics in such societies is embedded in practice and hence mathematics is implicit. Since this mathematics is implicit, it is impossible and incorrect to make a distinction between the idea and its applicability. More importantly it is impossible to decontextualize it (ibid).

Exploring and understanding the mathematical knowledge of these traditional cultures requires a broader definition of mathematics. Ascher (1994) feels that there is no clearly defined explanation or description for the term mathematics. Each group of people working on it arrives at a working definition which is often too narrow to be applicable in any other situation. Hence she put forward the notion of mathematical ideas that is more inclusive. Mathematical ideas "have to do with numbers, logic and spatial configuration and in particular, the combination or organization of those into systems and structures" (ibid p.37).

As the definition implies these mathematical ideas are embedded in culture and they cannot be separated from each other. This also implies that these ideas cannot be demarcated into categories which are outside to the culture nor can they be distinguished from other ideas in that particular culture. This interrelationship and interdependence between various ideas in a culture also suggests that there is no linear single path through which these ideas progress. Ascher puts it metaphorically:

> 'A single straight line is far too simple to serve as an image of how all these mathematical ideas are related to each other. For me, a possible visualization of their totality is the sounding, lighted mirror-faceted globe that is suspended from the ceiling of some ballrooms. Each of the thousand or so small mirrored facts is contiguous to some, but wieldy separated from others. Which facet catches and reflects the light at any given moment depends on where you are in the room' (1991 p.186)

Hence she argues that there is no basis in the arguments that Western mathematics is more developed than others, for 'Western expression is but one of many' (ibid p.2). Thus ethnomathematics, for Ascher begins with challenging the presumption of Western mathematics and calls for a broader understanding, contesting the perception of mathematics as the privilege of a few. Mathematical ideas exist in all culture but the way they are expressed and their context may vary in different cultures. An ethnomathematical perspective entails a broader understanding of mathematical ideas which helps us understand the diversity of human culture as well as enable us to reflect upon on important aspects of 'human ideation', for according to Ascher, "mathematical ideas are an important aspect of what it means to be human" (p.187).

Ascher's work also gestures towards several methodological dilemmas that challenge an ethnomathematical study. She observes that unless one is thoroughly accustomed to a culture, it is not possible to identify or understand all the mathematical ideas of that culture. For what we see as mathematics is what we know. There can be other ideas which are mathematical from the point of view of that culture but our mathematical understanding does not enable us to perceive that. Thus ethnomathematical studies need careful and detailed investigation and analysis and this distinguishes ethnomathematics from other ethnographic literature (1997).

Ascher's notion of mathematical ideas also implies that mathematics is thoroughly cultural and she argues that "mathematics could be even more powerful by retaining some recognition of what the symbols stand for and gearing the approaches used to that..."(p.39) instead of having symbols that can denote anything and have no context. This conception of mathematics challenges the abstract nature of mathematics and the practice of problem solving as performed in school mathematics. Ascher's idea on the broadening of the definition of mathematics converge with that of D'Ambrosio when she suggests that we go beyond the idea of problem solving and survival to include human needs and attempts to transcend the 'absolute corporal' also as mathematical activity. Like D'Ambrosio, for Ascher also, ethnomathematics "...has the goal of broadening the history of mathematics to one that has a multicultural, global perspective. It involves the study and presentation of mathematical ideas of traditional people" (1991 p. 188).

Ascher makes her point clear by stating that ethnomathematics is not a part of the history of western mathematics, because ethnomathematics looks at a broader category called 'mathematical ideas' than what is termed as 'mathematics' which is a purely Western construct and has a narrow and limited scope.

She further emphasizes the pedagogical potential of ethnomathematics, when she elaborates on two different aspects of ethnomathematics which are distinct but related and sometimes need to be more clearly separated (1994). In the first instance, ethnomathematics according to Ascher seeks to explore the relationship between mathematical ideas and culture. She says that this understanding requires an in-depth investigation and research and calls for a reflection on the historical and philosophical aspect. Once this understanding has been arrived on, the next step is to think of ways to incorporate this into curriculum which leads us to the second aspect of ethnomathematics-the educational aspect. Ascher shares her concern with D'Ambrosio that the contemporary mathematics curriculum is not contemporary at all and most of it is based on 17th and 18th century mathematics. She argues for a revitalization of mathematics education and in that process ethnomathematics can play a major role. However, she makes it clear that ethnomathematics does not seek to replace the school mathematics, but the aim is to "take a step toward a global, multicultural view of mathematics" (1991 p.1). Ascher is hopeful that this change in perspective is essential to the emergence of a philosophy of Western mathematics, which is true to the form and spirit of the contemporary era (1994).

Ascher also sees ethnomathematics as having increased potentials for adult education particularly so that people who are already socialized in a culture to draw upon their experience to learning situations and a curriculum which relates to the everyday experience of the learner.

2.7 Bill Barton

Bill Barton's works are more inclined towards exploring the philosophical basis of ethnomathematics and reflects an explicit concern for establishing ethnomathematics as a legitimate discipline. Barton, while reviewing the literature in the field of ethnomathematics points out that there are three dimensions to the contradictions and confusions that exist within the literature (Barton 1996). First is an epistemological confusion relating to the difficulties regarding the terms used to express the ideas about culture and mathematics. The second difficulty is philosophical. Barton feels that the philosophical nature of the field ethnomathematics has not been explored enough. The third dimension regards the lack of unanimity on the definition and meaning of the term mathematics. Without a framework in which all these confusions can be put into confrontation with each other, the progress of ethnomathematics as a field is not unhampered. Barton's work hence can be seen as progress toward this direction. The discussion of Barton's contribution taken up in this section is structured around these three dimensions. A fourth dimension concerns the political stance on ethnomathematics-this is also part of the discussion for Barton's discussion of the political nature of the subject is more nuanced and welds well with his efforts to seek legitimacy for ethnomathematics.

Barton views the relationship between culture and mathematics as multidimensional and argues that various dimensions of this relationship are emphasized according to the intentions of the authors (ibid). For him, the intentions of the authors form the focal point of any framework to discuss the relationship between culture and mathematics. Within this framework he argues that the relationship between mathematics and culture has to be analyzed at two different levels. At the first level, a distinction should be made between the writings on culture and mathematics education. At the second level, he identifies various strands in the writings on culture and mathematics itself. He points out four general areas which can be roughly classified as philosophical-work which mainly reflects on the nature of mathematics; culture which is also called cultural mathematics - deals with the "...nature of mathematical thought and activity in various cultures" (p 202); social anthropological-concerned about the evolution of mathematics and shows how the subject itself is a product of a particular cultural history and finally the political-or in other words the "politics of mathematics as a cultural issue" (p. 203).

He also identifies four distinct strands in the writings on culture and mathematics education.

- Activity curriculum development shows how a context specific, culturally embedded mathematics education can be more effective.
- Mathematics education embedded in culture-shows how the culture determines the nature of mathematics education; this can be roughly classified as sociology and anthropology of mathematics education.

- Social politics of mathematics curriculum; throws light on the relationship between society and mathematics education, emphasizing its political influences and consequences.
- Relationship between mathematics and mathematics education– "discusses the way theoretical paradigms in the two areas are related" (p.203).

Barton discusses the works of three major authors in ethnomathematic-D'Ambrosio, Paulus Gerdes and Marcia Ascher within the framework discussed above and tries to elucidate the nature of ethnomathematics-whether it is a body of knowledge, or a collection of practices? He observes that the "subject of ethnomathematics has shifted away from its initial conception as being the mathematics of particular cultural groups. The direction of this shift can be linked to the intentions of the authors and any congruence between them lie exactly where this intention overlaps" (p.206). Thus he surmises that ethnomathematics has developed into a research programme with broader area of reference and 'it now includes

a) The formation of all knowledge (D'Ambrosio).

b) Mathematics in relation to society (Gerdes) and

c) Mathematics ideas whenever they occur (Ascher).

(p. 210)

Barton maintains that the difficulty in identifying the subject of ethnomathematics arises because the referent is another culture. This makes the character and identity of the category-mathematics-problematic. "Colonial assumptions that all cultures have components which can be described in conventional mathematical term…" (1996 p.210) add to the difficulty. This lead to varied considerations regarding the nature and subject of the field as well as resulted in an unclear status for ethnomathematics vis-à-vis mathematics. For Barton ethnomathematics is "an interpretive programme between mathematics and culture" (p.213). It cannot be seen as a precursor to mathematics because ethnomathematics and mathematics are evidently distinct in their nature. Thus, summarizing his arguments regarding the nature of ethnomathematics, Barton puts forward a comprehensive definition:

> "Ethnomathematics is a research programme of the way in which cultural groups understand, articulate and use the concepts and practices which we describe as mathematical, whether or not the cultural group has a concept of mathematics' (p. 214).

Barton identifies four crucial implications of his definition implying a distinction between ethnomathematical study and mathematical study. Barton argues that ethnomathematics is more congruent with anthropology or history. The definition also implies a cultural specificity and thus depends on the context and intention of the person who is stating it. The practices that it describes are also culturally specific and finally it implies a sort of mathematical relativism (p.215) that is, it implies the coexistence of different mathematical traditions.

Having laid down a definition for ethnomathematics and also its implications, Barton classifies ethnomathematical studies around three dimensions of time, culture, and mathematics. Ethnomathematical studies exploring ancient or a contemporary culture can be clustered around the dimension of time, those which deal with a particular cultural group or a sub group reveals a cultural dimension and the mathematical dimension of the study is dependent on the relationship between ethnomathematics and mathematics. However, Barton agrees that all three dimensions are in a continuum and different ethnomathematical studies can be located at different point along that continuum (Barton 1996).

Whatever the nature of the study, Barton points out that there are four types of activities which are relevant for any ethnomathematical study. He classifies them as descriptive activity, archeological activity, mathematising activity and analytic activity. An ethnomathematical study may comprise all of these or any of these.

As has already been pointed out, Barton's work are more inclined towards seeking a legitimate ground for ethnomathematics and he does this by clearly distinguishing ethnomathematics from related areas of studies and by laying down its peculiar characteristics. The major challenge for ethnomathematics according to Barton is to clarify the relationship with academic mathematics and to locate ethnomathematics within the philosophy of mathematics (2004).

In every society, there are ways in which people make sense of quantity, relations and space. These are integral part of any society and the ways in which they are organized and expressed is intrinsically related to the culture of the society which is again dependent on the social and physical environment of the society (1994). Barton argues that conventional academic mathematics is only one way of registering these areas. The fundamental difference between conventional academic mathematics and other ways of mathematising lies in the formalized structure of the subject, which is only a different principle of organizing knowledge. The formalization has led to an abstraction of knowledge from its specific contexts and thus mathematics is dissociated from its humanistic character and assumes a rational character, whereas mathematics which lies in culture, which is not formalized, is embedded in practice and may not be recognized in abstraction or isolation. It is intrinsically related to the values and norms of the context in which it is applied. Ethnomathematics as a research programme seeks to bring out this human dimension in mathematics (Barton 2004).

Proceeding thus, ethnomathematics challenges the dominant understanding of mathematics and helps to extend the field of conventional academic mathematics. Barton agrees with Alangui (2003) by emphasizing that, the relationship between ethnomathematics and mathematics is that of a mutual interrogation, where interactions with academic mathematics may help to explore the possibilities of organizing ethnomathematics into a formal field, which according to Barton is very important in seeking legitimacy for the field. This process of interrogation also extends to philosophy of mathematics, since the existing philosophy of mathematics does not provide space discussions of mathematics within its anthropological and social context. Ethnomathematics envisages a philosophy which provides scope and space for discussing the possibility of simultaneous existence of different mathematics.

Barton puts forward an alternative model and calls it a "much more radical version of mathematical relativity" (1996). He introduces the phrase "QRS System" which refers to "the system of meanings by which a group of people make sense of Quantity, Relationship and Space" (ibid). Thus his model implies that every culture group will have its own QRS System and when groups interact, these systems also interact and a process of synthesis takes place. In this model of mathematics, Barton claims that there are "no presumed external 'mathematics' or rationality by which one system is judged better than another" (ibid). Barton proposes that Wittgensteinian philosophy of mathematics provides scope for his alternative model of mathematics. He argues that, Wittgenstein's idea that we 'talk mathematics into existence' helps to justify a position for ethnomathematics.

While proposing an alternative model for discussing mathematics, Barton is also concerned that the legitimacy of ethnomathematics as a field is largely dependent on the field of mathematics itself. Hence he suggests closer interactions between ethnomathematics and mathematics so that both the groups develop a more complex and detailed understanding of each other and this he feels will lead to the acceptance of ethnomathematics as a legitimate field of inquiry. Furthermore, he urges for an interaction of ethnomathematics with other 'ethno-fields' which have developed in various disciplines making the important point that ethnomathematics should also 'listen to the indigenous voices' (2010) for he realizes the limitations of a researcher who is an outsider to that particular culture.

Barton's understanding of the political potential of ethnomathematics emerges from the above concerns. Ethnomathematics has its focus, primarily on mathematics, on understanding how different people in different culture make sense of the quantity, relationship and space. This may have political implications because the question of colonialism and cultural hegemony will come up especially in the case of Third World countries. But that does not mean that ethnomathematics can be seen entirely as a political project. He puts it succinctly as 'challenging Eurocentrism in mathematics might be a consequence of this, but it is not, fundamentally, what ethnomathematics is about" (1999 p.33). He further argues that 'it is important for us as ethnomathematicians not be demonize conventional mathematics-mathematicians should be our debating partners and protagonists, not alienated by our words into dismissal or silence" (1999 p.34).

In his attempt to define ethnomathematics, Barton also makes a distinction between ethnomathematics and indigenous knowledge. According to him, indigenous knowledge is embedded in the culture of which it is a part and makes sense only within the world view of that particular culture. Any attempt to isolate this knowledge or to categorize it in terms of the world view of any other culture will result in a misappropriation of thin knowledge whereas ethnomathematics according to Barton lies at the intersection of two cultural groups. They try to relate the indigenous practice to conventional academic mathematics. In other words ethnomathematics tries to translate one world view into mathematical terms. Mathematisation is an important part of ethnomathematical activity. Indigenous knowledge and ethnomathematics are different, but there are links between them-one such compatible feature is the assumption of relativity which both of them entail. But Barton asserts that this "does not make them the same or necessarily dependent on each other, nor right" (2004).

Basic epistemological concerns that reflect in the works of other authors discussed in this chapter can also be traced in Barton's works. Barton also argues for a broader conception of mathematics and challenges the dominant philosophy and history of mathematics. Political aspects of ethnomathematical inquiry are also made explicit while greater emphasis is on the philosophical aspects.

The foregoing discussion serves to understand and analyze myriad expressions of ethnomathematics through the works of some of the prominent thinkers in the field. The relationship between culture and mathematics and a challenge to the hegemony of Western mathematics and education can be seen as a common theme in the writing of these authors. All the four authors seek to broaden the definition of mathematics. However, a brief overview of the contributions made by D'Ambrosio show that he began with a concern with mathematics education gradually moving towards a socio-cultural perspective on mathematics and subsequently questioned the dominant historiography and philosophy of science. His later works are more explicit about the potential of ethnomathematics to usher in a pedagogical and political change.

D'Ambrosio' works are seminal in the field of ethnomathematics. His conception of ethnomathematics and the epistemological, pedagogical and political role for ethnomathematics that he envisages was followed by numerous researchers in the field. However one is tempted to argue that the varied definition of ethnomathematics that D'Ambrosio puts forward will only add to the ambiguity about the nature of the emerging field rather than contributing towards its consolidation. Fossa (2006) argues that this tendency to define ethnomathematics so extensively is an attempt to make room for all the researchers who are attracted to the field. Though such a strategy may help in a rapid expansion of the field, he warns that such a trend may lead to a non-critical appraisal of what is passes as ethnomathematics.

Whereas Gerdes' concerns were rooted primarily in the political possibilities of ethnomathematics and for him the pedagogical aspect of ethnomathematics was a manifestation of the political aspect. The socio-cultural concerns reflected in his work also derive from this politics. Unlike D'Ambrosio and Gerdes, Ascher's concerns were mathematical implying epistemological and philosophical change and for her educational aspects of ethnomathematics are secondary to the epistemological aspect. Pinxten (1994) observes that Ascher's work from the standpoint of a mathematician complements the social science research on mathematics. "...Rather than describing the phenomena in terms of the culture or the psychology of the subjects, she goes the other way and describes the cultural and psychological data as arising from ways of dealing with the mathematical problems she recognizes". (p.24). Though Ascher's work is not explicitly pedagogical, Pinxten observes that, the link between the indigenous mathematics and academic mathematics that Ascher's work brings out provides a convincing ground for the pedagogical program of ethnomathematics.

Barton on the other hand emphasized the philosophical and epistemological aspects of ethnomathematics. This emphasis in Barton's work aimed at seeking legitimacy for ethnomathematics is well placed in Bourdieu's words: "To have a space of mathematical possibles that is recognized as mathematical by other mathematicians, you have to be a mathematician" (2001 p.60). However from a critical perspective informed by Foucault's theory of power/ knowledge, one is lead to argue that by urging to work on the structure and scientificity of ethnomathematics Barton is in fact defeating the purpose of ethnomathematics as a field. As Foucault points out, any attempt to rediscover the subjugated knowledges is possible only if the centralizing, hierarchizing power of scientific discourse is challenged. By trying to model ethnomathematics into the structure and form of scientific discourse Barton is proposing to inscribe ethnomathematics into the hierarchy of sciences, instead of emancipating it from that hierarchy and subjugation. Moreover, such an approach risks the autonomy of ethnomathematics as a field may open doors for the recolonization and recodification of these erstwhile neglected knowledges into the ambit of scientific discourse, for the relationship with power and knowledge is inscribed and maintained through this discourse (Foucault 1980).

Nevertheless, to put it bluntly, for D'Ambrosio and Gerdes mathematics education is the primary concern where as for Ascher and Barton mathematics is of prime importance and it is this difference in emphasis that mark the negotiations in the field through which it attains its form and shape.

2.8 Ethnomathematics- As a Field

Concisely, ethnomathematics can be identified in three dimensions-as a concept, as a pedagogical auxiliary and as a field. As a concept ethnomathematics refers to the mathematics embedded in the cultural practices of a particular group. It intends to establish that mathematics exists in all cultures. As a pedagogical auxiliary, ethnomathematics aims to revitalize mathematics education. It is used as an aide to help students to learn the rigorous conventional academic mathematics by linking mathematics to the learner's cultural background. As a field of study it lies at the intersection of various disciplines and conceives of a broader understanding of mathematical ideas and an alternative epistemology, thereby challenging the dominant fields of mathematics, its history and philosophy.

Various dimensions of ethnomathematics should be reckoned from the perspective of its relationship to conventional academic mathematics. When understood as the cultural practice of a particular group, ethnomathematics suggests that Western mathematics is also one of its manifestations. This leads to the argument that the term ethnomathematics is not appropriate enough and should be replaced by more precise terminology like African mathematics, Indian Mathematics or Chinese mathematics (Bishop 1990). However, considering Western mathematics as an ethnomathematics is also problematic because Western mathematics as a body of knowledge developed by harnessing the cultural traditions from different parts of the world (ibid). Understood as a cultural practice ethnomathematics fails to address these historical and political factors that underlie the process of knowledge production and organization.

A similar equation prevails when ethnomathematics is understood as a pedagogical auxiliary. The approach that ethnomathematics facilitates the understanding of academic mathematics and supports the hegemony of western mathematics, adding to the classical evolutionary perspective on the development of societies and their knowledge systems.

A philosophical and political dialogue with mathematics is pronounced when ethnomathematics is defined as a field or a movement. For it then goes beyond the questions of mathematics teaching and learning to explore the larger epistemological questions. This concern can be seen as reflecting in various works discussed so far. D'Ambrosio's program on ethnomathematics is an inquiry in to the process of production, organization and dissemination of knowledge. Barton argues that ethnomathematics has its grounds firmly in mathematics and observes that this is necessary to establish ethnomathematics as a legitimate field of study.

Following the above discussion this study conceives ethnomathematics as a field of study. The formation of the International Study Group on Ethnomathematics and the large volume of research work being published in the area suggest its importance as a field.

Varied connotations and the numerous dimensions of the term ethnomathematics that appear in the discussion so far, helps us understand the development of the field of ethnomathematics and the epistemological and political contestations it embodies. These various notions have to be analyzed as part of the process of negotiation of meaning and scope in an emerging field of study. As a struggle for specific, scientific and social capital that enables it to propose new cognitive forms that have the potential for transforming the power relations in the field (of mathematics) (Bourdieu 2004). Thus the attempts at boundary work are not only directed towards defining the field but also towards marking and maintaining its relative position in the larger academic field. The following chapter will elaborate more on this epistemological and institutional negotiation.

Chapter 3

The Field of Ethnomathematics

The last quarter of the twentieth century witnessed an intellectual movement that challenged the assumptions and categories hitherto employed in social sciences. The development of academic fields that focused on 'ethno' was part of this trend. Another development in the academic world characteristic of this period was an increasing relevance of interdisciplinary fields. New perspectives and new problems demanded new and different approaches that cut across various disciplines. Becher and Trowler (2001) refer to this as 'subject parturition'. "Subject parturition means that new fields develop from older ones and gradually gain independence. These may develop from one discipline or a number" (ibid p.14). They regard it as one of the features of growth of knowledge in what they call a post-industrial society. Another feature of the period was an emerging need to draw the contours of knowledge linking the local to the global (Raina et.al. 2009 p.4). Analyzing the field of ethnomathematics and the underlying epistemological and institutional dynamics provides an elaborate understanding of the field and also serves to understand the dynamics of knowledge production, organization and dissemination characteristic of the 'postmodern condition' (Barton 2004). This chapter is an effort towards such an understanding.

Bourdieu points out that "the notion of the scientific field is important because it reminds one, on the one hand, that there is a minimum unity of science and, on the other hand, that various disciplines occupy positions in the (hierarchized) *space of disciplines* and that what happens in them partly depend on these positions" (p.66) These disciplines are maintained by more or less codified dispositions characteristic of that particular discipline and sometimes are in a process of contest and consensus among other disciplines in the field. The intersection of these various disciplines provide scope for exchange of ideas and Bourdieu observes that "innovations in the sciences is often engendered in the intersections" (p.65). This chapter proceeds from this vantage point.

The first section of the chapter will try to understand the identity of ethnomathematics as an academic field. Different conceptions of ethnomathematics as a field are played out against each other in order to map the field. This is followed by an inquiry into the epistemological character of the field. A discussion of the interactions of ethnomathematics with other fields of study helps to explore the transdisciplinary nature of the field. The last part of the chapter attempts to analyze the institutional dynamics of the field through a discussion of the networks and organizations formed to further the interests of ethnomathematicians.

3.1 Epistemological Dynamics of the Field

"Fields of knowledge are extraordinarily resistant to prescription, and one which purports to acknowledge culturally diverse ways of knowing, is liable to develop its own rules in every new situation" (Barton 1999 p. 32). This volatile character of the field, which is more pronounced when it is an emergent one, makes it difficult to define ethnomathematics in a single tone, even though we have arrived at an understanding of it as a research program. We see various dimensions of program ethnomathematics in the works of various authors. Varied connotations can also be discerned in the works of a particular author.

For instance, D'Ambrosio asserts that the ethnomathematics program had different dimensions:

- Program in history and philosophy of mathematics with pedagogical implication (2008).
- Program in history of ideas and in cognition with clear pedagogical implication (D'Ambrosio 1988).

- Sub-field of history of mathematics and mathematics education with very natural relations to anthropology and cognitive sciences also with political dimensions (1985).
- Program in history and epistemology of mathematics with pedagogical implication.[29]

Even in a single work various dimensions of the program ethnomathematics can be seen. In one of his articles[30] he begins by saying that ethnosciences and ethnomathematics is part of a research program in history and epistemology with pedagogical implications and later moves on to argue that ethnosciences is part of ethnomathematics-a larger program on knowledge.

For D'Ambrosio ethnomathematics is a research program that goes much beyond mathematics and mathematics education to explore the nature of knowledge. In that sense he defines ethnomathematics as a program 'for understanding and explaining the generation, intellectual and social organization and diffusion of knowledge' (1985). In other words D'Ambrosio' research program is an inquiry into the 'history and philosophy of everything' and since mathematics 'is just about everywhere' he calls it ethnomathematics (ibid). He puts forward four categories to synthesize relevant research in ethnomathematics.

1. Research in culturally diversified environments.
2. Curriculum development projects and classroom applications.
3. Out of school applications and
4. Conceptual and theoretical foundations.

These tasks would help bring together relevant research from different parts of the world which are carried out under different names but align with the goals of ethnomathematics. This broad definition of ethnomathematics is more of a

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[29] D'Ambrosio *A Reflection on Ethnomathematics: Why Teach Mathematics*? http://vello.sites.uol.com.br/why.htm, accessed on 15/12/2010.
[30] D'Ambrosio *Ethnoscience and Ethnomathematics: A Historiographical Proposal for Non-Western Science* http://iascud.univalle.edu.co/libro/libro_pdf/Ethnoscience%20and%20ethnomathematics.pdf Accessed on 15/12/2010.

vision rather than that of a mathematician or an ethnomathematician, creating a space and context for research work on culture and mathematics. This serves the expansion of the field besides uniting researchers from varied backgrounds on a single platform.

D'Ambrosio also argues that multiple dimensions of the ethnomathematics program suggest that research on the field has to be tansdisciplinary and transcultural. Other works in the field also recognize this transdisciplinary nature of ethnomathematics though their description of the field is not as broad as those of D'Ambrosio. Gerdes (1999) defines ethnomathematics as the 'cultural anthropology of mathematics and mathematics education' and acknowledges its implications for history and philosophy of mathematics. Ascher also points out the implications of ethnomathematical studies for classical anthropological, historical and cognitive studies. On a general level, the transdisciplinary character of ethnomathematics can be described in D'Ambrosio's terms as "dealing with studies on the mind and cognition, anthropology, linguistics, history, epistemology, politics, education as well as some inter disciplines".[31] The transdisciplinary nature of ethnomathematics will be discussed later in this chapter.

The pedagogical implications surface as the major characteristic of the field after transdisciplinarity. This becomes very obvious when D'Ambrosio and Gerdes see it as a subfield of mathematics and mathematics education. In fact, D'Ambrosio recalls that the roots of his initial reflections on the field resided in deliberations on the socio-cultural and historical aspects of mathematics education. He also points out that ethnomathematics is directly linked to critical mathematics and multicultural mathematics education (1997).

The epistemological, historical and political dimensions of ethnomathematics are reflected prominently in several studies. For instance, Barton argues that 'ethnomathematics has its focus firmly on mathematics' (2004). This concern reflected in his definition of the ethnomathematics program, which is a

[31] D'Ambrosio *Alustapasivistykselitys or The Name Ethnomathematiics: My Personal View.* http://vello.sites.uol.com.br/alusta.htm. Accessed 15/12/2010.

"research program of the way in which cultural groups understand, articulate and use the concepts and practices which we describe as mathematics, whether or not the cultural group has a concept of mathematics" (ibid). Ascher and Barton, along with D'Ambrosio and many others assert the epistemological implications of ethnomathematics. For, by definition, ethnomathematics seeks a broader understanding of mathematics-thus affecting a change in the conception of the history and philosophy of mathematics.

The political potential of the field of ethnomathematics is the challenge posed to Eurocentrism in mathematics and thereby to restore the cultural dignity and self respect for non-Western cultures. D'Ambrosio (1985, 1997) and Barton (2004) argue that the major aim of the field of ethnomathematics is to reclaim humanism and values in mathematics. The emancipatory and social justice potential of ethnomathematics is more pronounced in the writings of Powell and Frankenstein and Paulus Gerdes. For Gerdes (1981) research in the field of ethnomathematics and its pedagogical applications catalyzes the process of cultural reaffirmation in the erstwhile colonized countries. Powell and Frankenstein view ethnomathematics as challenge to Eurocentrism and its various paraphernalia which in turn impinges on the various aspects of knowledge (1997).

3.2 Transdisciplinary Nature of the Field

The foregoing discussion suggests that the field of ethnomathematics lies at the intersection of various disciplinary fields like cognitive studies, linguistics, history, anthropology, sociology, philosophy and education. There have been attempts to understand and organize these various dimensions of the program ethnomathematics under a single rubric. In such a vein, D'Ambrosio holds that the field of ethnomathematics has six major dimensions-the conceptual, historical, epistemological, cognitive, educational and political. A somewhat similar picture of the field is suggested by Bishop (1999) when he identifies the major approaches in the field of ethnomathematics. For Bishop, there are three major approaches which he distinguishes on the basis of their emphasis. These include:

a) The anthropological approach which emphasizes uniqueness of mathematical knowledge in different cultures.
b) The historical approach-which explores the past to shed light on the mathematical knowledge of non-western societies.
c) The Socio-psychological approach that focuses on the construction of mathematical knowledge of different groups in a society.

Bishop argues that these distinct approaches are united by an underlying epistemological question that impinges on the relativity of mathematics, in other words the basic question is whether there are different mathematics, or are the mathematical ideas in different cultural traditions various manifestations of one mathematics? (1999).

Ron Eglash proposes a slightly more nuanced understanding of the field of ethnomathematics. Eglash sees "ethnomathematics as one of five distinct subfields within a general anthropology of mathematics...." (1997 p.79). Research in ethnomathematics is cross-disciplinary and the insistence on epistemological and socio-political conflict in ethnomathematical research distinguishes ethnomathematics from other subfields of the anthropology of mathematics. It is interesting to point out here that D'Ambrosio (1985) had earlier urged for the development of a field which he had then called anthropological mathematics. He had proposed that anthropological mathematics with social history of mathematics, cognitive theory and cultural anthropology serve to identify within ethnomathematics a structured body of knowledge.

Ethnomathematics is defined variously as a subfield of anthropology of mathematics, as a subfield of cultural anthropology of mathematics and mathematics education and sometimes as a subfield of history and philosophy of mathematics. Thus it emerges that ethnomathematics is a transdisciplinary field–one that "transcends disciplinary and interdisciplinary forms..." by creating a new conceptual framework thereby implying changes to more than one discipline (Raina et.al. 2009 p.9). To understand this transdisciplinary character of the field is the aim of the next section. In the following section ethnomathematics is discussed with reference to some other disciplinary fields to understand the nature of interaction.

3.3 Transdisciplinarity

Ethnomathematics is variously referred to in the literature as a transdisciplinary field, a multidisciplinary field and sometimes as a interdisciplinary field. Without going into the nuances of each of these qualifiers, this section explores the interrelationship of ethnomathematics with different disciplines. The foregoing discussion suggests that different disciplinary fields intersect with ethnomathematics at different points and ethnomathematics has a bearing on the content and identity of these fields. The following section attempts to locate the points of intersection between ethnomathematics and other disciplines. The attempt here is to map the theoretical and methodological issues that emerge in this interaction and have implications for the concerned fields.

3.3.1 Ethnomathematics and Anthropology

The relationship between ethnomathematics and anthropology seems very obvious. This is partly because of the prefix-ethno, for our conceptual baggage which is still predominantly modern associated the term 'ethno' immediately to the 'other' (indigenous, tribal, primitive) which is the subject of anthropology.

The relationship between ethnomathematics and anthropology has been discussed within the field. There have been attempts to see ethnomathematics as 'cultural anthropology of mathematics and mathematics education' and at time ethnomathematics emerges as one of the perspectives in the anthropological study of mathematics. This interrelationship emerges from the assumption that mathematical ideas are formed as part of the process of cultural activity of human beings; hence mathematics is a cultural activity and thus is amenable for cultural interpretation. It has also been discussed in the conferences and seminars on ethnomathematics. Discussion groups at ICME (International Congress on Mathematics Education) and ICEm (International Conference on Ethnomathematics) sessions have the "relationship between ethnomathematics and anthropology" as one of the thrust areas. The implications of these fields to each other are debated prolifically.

Anthropology has been a major source of distinction between the West and the Non-West. In its endeavour to interpret cultures anthropology was also marking cultures into various binaries of primitive/civilized, modern/traditional, native knowledge/science etc. (Nader, 1995). The marking, categorizing and stratification of cultures and various aspect of it is more explicit in the case of science. Anthropological analysis distinguished magic, religion and science. The realm of magic and religion which was considered irrational was imputed on non-West cultures. Laura Nader (1996) gives an elaborate discussion of the role of anthropologists in establishing this myth of primitive savages incapable of doing science. Sujata (2007) observes that "anthropologists accord differential treatment to folk conceptions or the understanding of lay people, in different spheres of life. In the domain of religion, folk conceptions are regarded as legitimate and valid and are treated with appropriate gravity. But in the domains deemed to be scientific, such as medicine, physiology, agriculture and architecture, folk conceptions tend to be treated mainly as 'subjective' beliefs and not as valid forms of knowledge" (p.169).

The change in the perspective on knowledge ushered in by the 20th century political and epistemological shifts sought to debunk this myth. Nader's book is an excellent instance for this. The title of the book *Naked Science:-Anthropological Inquiries into Boundaries, Power and Knowledge* (1996) is suggestive of the new role of anthropology in the study of science and knowledge. A newly found interest in indigenous knowledge aims to establish that, local knowledge systems and cultural practices cannot be examined within the benchmark laid down by West. Anthropological inquiry was extended into the study of Western science itself. Ethnographic studies of laboratory (Latour and Woogler 1986, Cetina 1981) and scientific practices reflected the critical gaze back to West. The hegemony of western knowledge was challenged; ethnomathematics also emerged as part of this challenge.

There have been several anthropological works on the mathematical ideas of the non-Western culture. But most of these studies fall short of systematic analysis because they were driven more by a 'paternalistic curiosity' (D'Ambrosio1997) rather than a genuine interest to explore the underlying structures of knowledge. Ascher and Ascher (1997) points out that "most anthropologists were limited in their understanding of mathematics and have seldom asked relevant questions" (p.34). They argue that such anthropological studies are based on the classical evolutionist paradigm which supposes a unilinear evolution of human species and assigns non-Western cultures toward the tail end which are then labeled as primitive. In this perspective primitive people are not capable of 'higher culture' (Nader 1996).

Knijnik's and Eglash's critique of cultural evolution is more nuanced. Knijnik argues that ethnomathematics questions the concept of culture itself, "it moves away from a traditional view that expresses culture as a humanity's cultural heritage" [32] This view of culture assumes a consensus regarding 'whose heritage' and eventually this cultural heritage. Mathematics, is especially is projected as the heritage of - "the Western, white, male, urban and heterosexual man" (ibid). By focusing on other small scale cultures ethnomathematics problematizes this consensual conception of 'the culture'

[32] Knijnik, G, *Ethnomathematics And Postmodern Thinking: Conver/Divergences*, http://www.nottingham.ac.uk/csme/meas/papers/knijnik.html Accessed on 13/03/2011.

and puts forward an alternative concept of culture which identifies diversity in cultural heritage. Eglash argues that the concept of cultural evolution as a linear process fails to capture the argument put forward by ethnomathematics. Ethnomathematics conceives cultural evolution as a 'branching diversity of form' (p.82). In his own words, "evidence for complex mathematical ideas in small scale societies requires seeing cultural evolution as a bush, not as a ladder, since the mathematics that blossom on later branches in some societies may be on earlier branches in others" (p.83). Raina (2003) observes that the linear conception of history of human evolution was in fact an important feature of history of science in early twentieth century. It was preoccupied with a "...chronicle of reason ...founded on the fundamental European 19th century trope, according to which the history of science as a history of the progress of humankind could subsume the history of human thought and civilization" (p.85).

Eglash (1997) while discussing the various sub-fields of anthropology of mathematics points out the uniqueness of ethnomathematics that result from a mediation of both cultural and epistemological issues. These issues refer to both modernist and post-modernist approaches to mathematics. By pointing out the existence of mathematics in non-western societies like China, India, or the Islamic empire ethnomathematics challenges Eurocentrism. But simply extolling the mathematical advancements of these empire civilizations does not challenge the racial prejudices and may also lead to a more romanticized picture of these societies which Said (1978) calls Orientalism. For Eglash ethnomathematics is a perfect balance of these two positions as it concerns this small scale indigenous society. Gelsa Knijnik also discusses the 'ambivalent fluctuation' of ethnomathematics between modernity and post-modernity. Following Skovsmose and Vithal (1997) she critiques ethnomathematics for not paying attention to the internal power politics of 'identifiable cultural groups' whose homogeneity is taken for granted. Knijnik argues that cultural and epistemological critique put forward by ethnomathematics stems from a post-modern perspective and hence it is important to pay attention to power-relations not only in the West-non West interactions but also within a particular society and its different cultural groups.

Darlinda Moreira, reviewing the relationship between ethnomathematics and anthropology, point out several points of intersection between the two fields. According to her, both the fields share:

- "An important object of study, which is local systems of knowledge that might be related to mathematics or are, invoked mathematics.
- An important corpus of literature and the same seminal key concepts such as culture, conception, interaction and local knowledge.
- A characteristic seminal feature of the use of participant observation as the most provincial research methodology.
- Moreover there are important issues that are considered in these two fields that are also important issues in mathematics education and in education, in general, such as learning, cognition, literacy, human rights, diversity and multiculturalism".[33]

While focusing on the cultural foundations of mathematics, ethnomathematics also raises several theoretical questions as 'where to draw the line between mathematics and cultural practice?' (Barton 2004). In an attempt to answer this question Barton suggests an epistemological and structural difference between 'mathematics' of a professional mathematician and that of an artisan who uses mathematical ideas in his/her vocation. In order to make sense of this epistemological disjuncture Barton suggests for a mutual interrogation of the two knowledge systems, which is best achieved by a native practitioner who is also well versed in mathematics. Barton says that it is important to 'listen to the indigenous voices' as indigenous knowledge is embedded in a world view which cannot be comprehended from the framework of a different worldview. As it emerges, Barton is raising one of the vigorously debated

[33] Darlinda Moreira - *Explorations between Ethnomathematics and Anthropology in Relation to Mathematics Education* http://dg.icme11.org/document/get/324 Accessed on 13/03/2011.

methodological dilemmas in anthropology-studying the other. Postcolonial anthropology had challenged the 'objectivity' of the colonial gaze and led to several novel perspectives like 'decolonizing methodologies' (Smith 1999).

To sum up the discussion on the relationship between ethnomathematics and anthropology, it can be said that ethnomathematics as a field of study intersects with cultural anthropology at several junctures. Ethnographic studies are valuable sources of data for ethnomathematical analysis, but as put down by D'Ambrosio, the goal of ethnomathematics goes much beyond ethnographic studies. Ethnomathematical investigation does not stop with collecting ethnographic data. In fact, the interrogations of the underlying structures of knowledge begin with ethnographic facts. Ethnomathematics goes deeper into the underlying dynamics of knowledge production with its focus on the cycles of knowledge production and organization, and thereby goes beyond anthropology in studying local cultural practices and knowledge systems. Another major difference between anthropology and ethnomathematics lies in the scope within ethnomathematics to explore the mathematical cultural practices of cultural groups within urban societies, like that of carpenters, architects etc.

In short, anthropology informs ethnomathematics to a great extent and ethnomathematics in turn broadens the scope of anthropology (of science and mathematics). Nevertheless, ethnomathematics as a field has been able to carve out a separate niche, which cannot be subsumed under cultural anthropology or anthropology of mathematics.

3.3.2 Ethnomathematics and History

'What is usually called history of mathematics should be called history of European mathematics" (D'Ambrosoio 1998). Ethnomathematics begins by rejecting this premise and suggests that history is intrinsically biased as an academic field in that it reduces the history of non-Western societies to a

Eurocentric framework, which denies them any sense of respect or dignity about their past. This is especially true in the case of history of science and technology as well as for history of mathematics. Raina (1999) explains that the traditional approach to history of science was based on a centre- periphery model which was couched in a linear account of the diffusion of knowledge from centres to the periphery. These theories lack an interactive approach (ibid) and "misses out the multifarious nature of exchange between modern science and so called traditional knowledge forms" (2007 p.xvi).

The dominant historiography of science and mathematics is based on the synthesis of ideas in the Mediterranean basis. The history of these ideas is traced as an autonomous field and the contribution of other cultures to the process and product of knowledge production is completely ignored. D'Ambrosio understands this as a strategy of colonialism. To negate the self and identity of colonized is an important strategy of domination. To deny the colonized peoples any scene of history and culture is the most powerful tool of this strategy.

In the late 20th century the postmodern condition (Barton 2004) opened spaces for relativist perceptions of history and other hegemonic discourses. Dominant historiography was critiqued for its intrinsic ideological and methodological biases. The momentum thus created called for a more democratized approach to history that gives importance to the local and also raised a need to contextualize the historiography of science (Raina 2003). Ethnomathematics and its relationship to history have to be understood in this broad framework.

In the case of mathematics, the dominant historiography "virtually ignored the mathematics of non-European cultures" (Selin 1997) even though there was enough evidence of the contributions of non-European cultures to the development of the ensemble that is understood as mathematics today. Whatever faint signs of acknowledgment were restricted to some rudimentary geometry, algebra or numeration. George points out that most of the scholars even in Indian universities were unaware of the contribution of Kerala School of mathematics (2011).

Bernal (1997) notes that "there is little doubt that this modern view of Egyptian's lack of mathematics and science has been influenced by a distaste for the theology and metaphysics in which much of Egyptian and platonic knowledge was embedded and by progressive view that no one who lived so early could have been so sophisticated. It may also have been reinforced by assumptions, almost universal in the 19^{th} and 20^{th} centuries that no Africans of any sort could have been capable of such great intellectual achievement" (Bernal 1997 p.89)

The conviction behind this was a 'colonial mentality' (ibid) rooted in racism and prejudices, and held others incapable of higher levels of abstraction, which is defined as a precondition for mathematics. Any possible contribution of non-Western mathematics to Greek mathematics was out rightly rejected. It was seen just as the "scrawling of children just learning to write as opposed to great literature" (Kline 1962 quoted in Joseph 1991 p.8). During the late 20^{th} century several woks came out, which challenged European hegemony in science and technology.

Historiography in this new line of inquiry can be distinguished for their different emphasis (ibid). One line of inquiry attempted to establish that 'what is called European mathematics is in fact an amalgamation of mathematical ideas from various part of the world. (Bernal 1987). Another trend attempted to bring out mathematics in cultural practices which are not recognized as mathematics in the dominant historiography of mathematics. Helaine Selin (2000) points out that most of the works on non-Western mathematics focus mostly on cultures whose mathematics has contributed to western mathematics. Eglash (2000) also makes a similar point when he points out that most of the works on non-western mathematics are concentrated on India, China, and Arab countries, Egypt etc. Though this counters the Western supremacy, it leaves the racial prejudice in mathematics in fact, because all these non-Western societies are state empires and this in a way, reinforce the determinative view on mathematics, which relates higher mathematical abilities to the development in political and economic structure of the society. This in a way, amounts only to shifting the target of prejudice, to non–state traditional societies rather than countering it. However, ethnomathematics eschews such determinism and provides scope and space for discussing mathematics in all cultural environments. Wood (2000) illustrates this point with his excellent analysis of the mathematics in societies without written communication. Wood also elaborates on the methodological and theoretical issues involved in such an attempt.

The major aim was to counter the reductionist definition of mathematics and its historiography. Current historiography and its framework do not provide scope for understanding knowledge-mathematical knowledge in this perspective. The methodology which is largely based on written sources and driven by fixation on names, dates, places and events hardly throws light on cultural aspects of knowledge. However, the line between these two tends is narrow and problematic because as Ascher (1997) and Barton (1996) point out, the category called mathematics is Western and to impose this category on the indigenous ideas is to impose its hegemony. Nevertheless, it is important not to fall prey to naïve relativism which refutes any ground for cross cultural comparison.[34]

Ethnomathematics as a research program in history and philosophy of science and mathematics impinges on all these issues in the historiography of mathematics. D'Ambrosio calls for a new historiography that captures the process of knowledge production, organization and dissemination in a broader perspective, as envisioned by the Annales School of thought. For D'Ambrosio knowledge, particularly mathematical knowledge is embedded in culture. It is a product of human urge for survival and transcendence. Hence, it develops in tandem with the natural/cultural environment. This results in cultural

[34] For an elaborate discussion on this see Raina 2007.

specificity of the knowledge produced, which is in a symbiotic relationship with other realms of culture.

D'Ambrosio's proposal is an alternative historiography that looks into categories like, "memories, myths, and the divinatory arts (techniques, behavior, communication, language, traditions, history, religions, systems of values, science) to make sense of the past" (2000 p.79). 'History thus gains a new breadth, for the concept of sources has to be changed and amplified, and chronology has to be entirely revised in order to include developments which followed different, in many cases, unrelated lines" (1997 p.14).

Ethnomathematics' historiographical proposal seeks to broaden the historiography of mathematics and also questions the definition of mathematics and challenges the set of values associated with it. This challenge arises from the conviction that Western mathematics, defined in a narrow sense excludes mathematical traditions in non-Western culture. Joseph (2000) notes that 'omission and appropriation' and 'exclusion by definition' were the strategies followed to establish the hegemony of Western mathematics. Mathematical traditions which did not follow the axiomatic/deductive forms were thus excluded from the definition of mathematics. This was also accompanied by a set of values which was also rooted in the Western culture. Thus idealist and elitist values (ibid) "led to philosophical dichotomies such as to know /to do, manual work/intellectual work, mind/body etc" (D'Ambrosio 1994 p.39). Ethnomathematics rejects this prejudicial value and questions the historical shortsightedness that led to this narrow definition of mathematics. Bernard (1997) also calls for a less circular definition so as to include the mathematical contribution of non-Western culture.

Ethnomathematical investigation includes exploring the possibility of transmission of mathematics from non-Western culture to Western cultures which was later synthesized into what we know as mathematics today. It attempts to expose the non-Greek roots of great mathematicians who are supposed to be Greek though there is enough evidence to suggest otherwise.

To claim these mathematicians of Greek origin only because they wrote in Greek was part of the colonial strategy to justify their intellectual repository, while negating a similar past to the colonized people. Lumpkin (1997) comments that "their use of Greek makes them no more European, than the use of English by Nigerians today changes that nationality" (p107).

The historiographical proposal put forward by ethnomathematics, has special relevance to erstwhile colonized nations, which are in the process of cultural reaffirmation (Gerdes 1981). It investigates the politics behind transfer to knowledge to the peripheral nations has also to be analyzed. D'Ambrosio puts forward a framework for such an analysis which he calls the basin metaphor.[35] Basin metaphor conceives of the process of knowledge production and dissemination in terms of the metaphor of a river and its basins.

"The main producers of knowledge (central nations) are represented by the main stream. The water fertilizes their margins. They will produce their effect in the margins of the tributaries (peripheral nations) much later, when the water have already flown along the stream (thus producing the gap of obsolescence of knowledge). The water (knowledge) does not flow upstream of the tributaries" (ibid).

The methodological and theoretical propositions put forward by ethnomathematics also enables the analyses of mathematical knowledge of small scale traditional societies as well as the cultural group within a society. Gerdes (1981) argues that history of mathematics is conspicuous with the absence of marginalized section of the people. Gerdes' (1998) and Fasheh' (1997) work on the mathematical ideas embedded in cultural practice like weaving, knitting, basket making etc. attempts to bring women back to history of mathematics. Ethnomathematics also implies a more critical perspective for history of mathematics education (Gerdes 1981, D'Ambroiso 1985). History

[35] D'Ambrosio *An Adequate Historiography for Non- Western Mathematics*, http://vello.sites.uol.com.br/adequate.htm Accessed on 15/12/2010.

of mathematics education sheds light on the process of institutionalization of different systems of knowledge.

Ethnomathematics and history of mathematics inform each other as well as broadens the scope for each other's inquiry. History of mathematics from an ethnomathematical perspective can have great implications for the understanding of knowledge itself. Such a perspective calls for a broader understanding of sources of history, and shall include "investigating pre-colonial practices, as identified through movements, artifacts, documents and practices among communities with strong cultural roots" (D'Ambrosio 2008). Thus ethnomathematics questions the basic methodological and theoretical promises on which the current historiography of mathematics is based. It calls for a history from below, which is hitherto neglected by the dominant historiography of science, technology and mathematics.

3.3.3 Ethnomathematics and Sociology

"We must discover the way all factors-sociological, logical, artistic and personal - that have played a role in the case under investigation, never forgetting, however that man is a social being even when he worries about the straight lines on hyper cones in seven dimensional space" (Struik 1942 p.70). That was Dirk J. Struik writing in the year 1942, arguing a case for sociology of mathematics. We also know of Spengler who way back in 1936, argued that mathematics is culturally rooted. Struik mentions the work of scholars like Sombart (1913), Bukharin (1922), Klein (1926) and Hessen (1931) who attempted a sociological explanation for the development of mathematics. Curiously enough, the image or rather the 'aura' of mathematics as an abstract, 'disinterested' and 'pure' intellectual activity remained intact.

"Mathematics is the oldest science to develop a rigorous-even rigid-idea of its own practice, so that the scientificity of mathematics has come to seem not so much historical as natural after 2500 years" (Hodgkin 1986 p.175). Restivo

(1992) attempts to debunk this myth of natural abstractness of mathematics and argues for a strong sociology of mathematics which is based on the foundations laid by Spengler and Durkheim. He draws from Durkheim's idea of collective representations and argues that mathematical representations are social constructions. Restivo engages in a social history of the subject to show how the abstraction and rigor in mathematics was a product of the Greek and later the European culture where it flourished. He argues that the political and economic conditions in the Greek civilization during the BC 600s enabled the development of an 'increasingly elitist' and a self sustaining intellectual community who could engage in intellectual activity, away from the chores of mundane existential troubles. This led to a separation of intellectual and manual labor and reinforced the ideology of purity and the idea of abstraction. Struik (1942) also makes a similar argument.

Restivo (ibid) also gives a sociological explanation for the rigor in mathematical practice, which was a result of the emphasis on proofs, and axiomatic deductions which resulted from competitions involving mathematical puzzle and proofs-which was part of intellectual leisure activity in Europe. By providing a sociological explanation for the values of abstraction and rigor, Restivo can be seen as establishing the ethnomathematical hypothesis that western mathematics is but only one ethnomathematics.

Grabiner (1947) attributes rigor in mathematics to the professionalization of mathematics. According to her, rigor became an important attribute of mathematical activity toward 1800s which corresponds to the period when majority of the mathematicians started to take up teaching of mathematics as a profession. An activity, which earlier required production of proofs and solutions, now required a systematic basis so as to make sense to the students. She explains that professionalization of mathematics also required a demarcation from the outsiders - and the self-taught competitors. Thus the rigor which mathematicians claim as the hallmark of their mathematics is nothing but an outcome of the social organization of the profession of mathematics (Martin 1997).[36] Thus the abstraction and rigor, so adored by western mathematics is nothing but a cultural product of the society in which it is rooted. Ubiratan D'Ambrosio gives a historical explanation of this development (1985, 1997)[37].

The early 20th century philosophical debate regarding the foundations of mathematics also contributed to separate mathematics from the real world (Struik, 1986). The dominant views in the philosophy of mathematics like formalism, Platonism, logicism, and intuitionism did not provide any scope for a conception of mathematics that was socio-culturally determined. The debate in the traditional literature on philosophy of mathematics mainly rendered around "the nature of mathematical objects and our means of knowing them, and the search for free mathematics from paradox and uncertainty" (Barton 1994 p.4).

The fact that mathematics as practiced by the mathematicians is rarely; fully comprehensible to outsiders immunized the field from any sociological investigation. Martin (1997) shows that specialization and professionalization of mathematics serves the social interests of the ruling class, as it exclude outsiders and hence from any public scrutiny of the ideas. He cites the instances of how mathematical modeling and statistics are used as a final justification for the policies and practices. If something is justified mathematically then that is final. Mathematicians also try to project a picture of the subject which requires a genius, well above the average human mind.[38] However, these are only attempts of a professional class to maintain its boundaries and monopolies and shall be a resourceful topic of investigation for sociology of professions.

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[36] Most of the ethnomathematical and multicultural mathematics efforts in mathematics education is critiqued for not maintaining the rigor of the discipline.

[37] See chapter 4 for more on this.

[38] Films and fiction portray mathematicians as eccentric. Eg. 'Beautiful Mind' (film), Logicomix (children's literature).

Another myth that gives a 'crest of peacock' (Joseph 1991) status to mathematics is its 'unreasonable effectiveness' in solving the problems of the physical world (Sarukkai 2005, Barton2010). Sarukkai explains how applicability of mathematics in physical sciences endorses a kind of mysteriousness and obviousness to mathematics which results in a belief in the unreasonable effectiveness of mathematics. Barton sees this 'surprising usefulness' a result of the adaptation and evolution. Sarukkai (2011) also contends that the resistance to ethnomathematics is stronger than other ethno-fields because it challenges the universality and authority of mathematics upon which the authority of science is based and which subsequently offers the model for social sciences as well. However Hodgkin (1986) makes a different point. He observes that "there is beginning to grow up an increasingly critical reflective viewpoint on the practice of mathematics itself. And the people, who work in the field are the first to see that this viewpoint makes sense. They see that mathematics is less a hard crystalline mountain of truth painstakingly built up by successive generalisations than a field for error, for the conflict of ideas, for vagueness, for continual approximation and conjecture as the means of progress. So it is recognised among mathematicians, if not outside, that we do mathematics one way but we might well do it another" (p.174). Collins and Restivo (1983) also argue on similar lines. According to them, the history of western mathematics is largely characterized by 'paradigmatic pluralism'. "The long term trend in the Western mathematics has not been towards a single, dominant paradigm, but rather towards rival schools at odds over fundamental questions about methods and knowledge" (p.221).

By questioning and exposing the claims on which mathematics is based, sociology has not only provided a fertile ground for ethnomathematical inquiry but also suggests methodological and theoretical propositions to proceed with. David Bloor (1991) puts forward his 'strong program in sociology of knowledge'. Bloor's 'strong program' derives insight from Durkheim, Manheim and Znaniecki. He elaborates that the strong program shall aim at a causal explanation of knowledge. It should be impartial and symmetrical in explanation and should be reflective in the sense that theory should be applicable to itself. These four tenets of his strong program, Bloor argues shall provide the framework for a sociological investigation of any scientific discipline including mathematics. Applying his strong program on mathematics, he elaborates on John Stuart Mills' position that mathematics is based on physical models and human experiences, and investigates the history of mathematics to explain how the "...truths' of mathematics are maintained as 'compelling, unique and unchanging" (p.85). Situating Western mathematics in its historical and sociological context, Bloor searches the possibility for an alternative mathematics-which is not possible until the compelling and unique nature of mathematical truth is exposed and questioned. Anything which does not fall in line with the explanations and methods of mathematics was rubbished aside as error, common sense or not-mathematical enough. Bloor's exposition of the nature of mathematical truth and its status is a convincing ground for ethnomathematics to carry forward its arguments.

Brain Martin (1997) argues for an inquiry of mathematics that locates mathematics in its social organization and tries to uncover the relationship between social interests and mathematics. He points out certain social features related to mathematical expertise like the sources of patronage, professionalization, specialization, male dominance etc. which can be traced to having determined the choice of area of study and development of mathematical frameworks. He argues that only a study which tries to trace the dynamics of social interests underlying the mathematical enterprise can arrive at a comprehensive understanding of mathematics in the modern world. Martin's arguments are important for ethnomathematics, especially in investigations in urban societies and in its attempts to explore the potentials of an ethnomathematical curriculum.

A cursory review of the literature on sociology of mathematics shows that the propositions put forward by these various studies concur with some of the insighst concerning ethnomathematics. D'Ambrosio' project on ethnomathematics starts from his concerns regarding the socio-cultural goals of mathematics education. Zaslavsky (1973) had earlier named the field socio-mathematics. Alan Bishop' thoughts were focused on mathematics enculturation. Powell and Frankenstein draw links between ethnomathematics, racism, class and gender in mathematics education. D'Ambrosio' later works which connect ethnomathematics to peace, democracy and cultural rights also demonstrates a sociological understanding. Sociology of education and sociology of knowledge have served as a launching board for ethnomathematics. It is important to note that sociology provided a well developed conceptual and theoretical grounding for ethnomathematics. However, a general trend in ethnomathematical literature tends to overlook this vital relevance of sociology of mathematics and the methodological issues it raises.

The majority of ethnomathematical work with whatever sociological orientation can be categorized as what Restivo (1992) calls 'the weak sociology of mathematics'. Weak sociology of mathematics also contends that mathematics is socially constructed but most of the studies concentrate on areas like 'out-of-school mathematics' that attempts to explore the mathematical ideas embedded in cultural groups and their practices especially in urban societies. They attempt to argue that every culture has its own mathematics. But that does not amount to challenging the hegemony of Western mathematics, without which all claims of ethnomathematics may go unheard. It requires a lot more sociological and philosophical investigation and reflection (ibid).

In her article, *Ethnomathematics Vs Epistemological Hegemony* Ana Dias (1999) explores the mathematical practice of a home designer and builder and points out that there are different mathematics and also different ways of doing it. She argues that "these idiosyncratic ways of mathematizing, whether pertaining to individuals or to entire cultural groups, should be recognized and legitimated in mathematics classrooms" (p.32). Following Turkle (1984) she distinguishes between hard mastery and soft mastery and suggests that the builders are soft workers. She also uses this category to explain the gender biases in mathematics education by explaining that girls are soft programmers. She says that "the realization of soft and hard styles of mastery invites us to challenge the hegemony of abstract and formal reasoning in mathematic" (p.26). However, one is tempted to argue that mere realization of different styles of mastery does not challenge the epistemological hegemony of mathematics. The question why certain groups have hard mastery and what is the relationship between hard mastery and soft mastery is left unattended. This in turn serves to reinforce the racist and pedagogical hegemony of mathematics. To argue that girls are soft programmers without exploring the reasons for that particular attribute in girls will amount to lapsing to the deterministic view about the capabilities of women.

Thus the methodological and theoretical premises put forth by sociology of knowledge and particularly sociology of mathematics can provide useful insights for ethnomathematical endeavor. Or the other way round, ethnomathematical inquiry serves to substantiate the propositions of sociology of mathematics. In other words ethnomathematics carries forward the investigation of sociology of mathematics.

3.3.4 Ethnomathematics and Cognitive Psychology

Like sociology, history and anthropology, ethnomathematical inquiry in cognitive psychology and linguistic begins by rejecting the assumed authority and supremacy of Western mathematics and the conception of cognitive disposition that it posits. Walkerdine (1997) exposed the discursive practices that underlie this image of mathematics and Saxe (1999) and Lave (1996) among others substantiated that mathematics exists outside the school also and that it is as reasonable, rational and effective as school mathematics. Ethnomathematics follows this critique of scienticism and notions of superior-inferior that pervade mathematics and psychological research on mathematics.

Seeking explanations for poor mathematical performances of people from particular social groups like women and working class children is one of the major thrust of psychological studies of ethnomathematics. Ginsburg's (1997) analysis of psychological research on poor children's cognitive abilities shows that most of the data and methodology used for the studies which flourished in late 1960 and 1970s was flawed and led to flawed conclusions. He rejects liberal environmentalist' and naturist' notion of cognitive deficit-the argument that the deprived environmental conditions of poor children produces a cognitive deficit. Debunking the 'myth of a deprived child' and he puts forward the idea of cognitive difference, arguing that poor children do not suffer from any cognitive deficit and develop cognitive abilities distinct from that of the middle class children. This perspective calls for a broader understanding of the learning process which goes beyond cognitive notions to "genuinely psychological and ecological considerations" (ibid p.149).

Walkerdine (1997) adopts a post-structuralist position and invokes Foucault, Lacan and Bhabha to argue that subjectivity is not pre-given, but located in practice. She urges abandoning the "view of the pre-given subject with skills and pre-social models of human cognition altogether" (1997 p.202). Walkerdine's position is basically a critique of the mainstream theories of cognitive development and the idea of child development, that assumes a fixed sequence of development from higher to lower, from concrete to abstract, without giving due importance to the intervening socio-historical factors. Following Foucault, she examines the various discursive practices that create the notions of abstract/concrete, normal/pathological and so on. The process of subjectification is examined following Bhabha and Lacan. What Walkerdine argues is for a better understanding of mathematics education which understands the politics of subjectification and self regulation which underlie mathematics and its discursive practices. For this she argues for abandoning the notion of the stages wise development which is an offshoot of the classical evolutionist paradigm and reinforces the prejudices of supremacy and inferiority of cultures. This critique of mainstream cognitive psychology informs ethnomathematical investigation premised on the idea that understanding of education is deeply entrenched in one one's living environment.

D'Ambrosio's program of ethnomathematics is an enquiry into the history of ideas and cognition. It tries to understand the diverse ways of thinking and explaining the manner in which people simulatenously engage with survival and transcendence. This very idea underlies the use of the term ethno-mathema-tics. A cycle of knowledge: reality-individual-action-reality (Sinha 1993) is based on an understanding of cognitive evolution which is related to environmental specificity. D'Ambrosio (2006) argues that cognitive evolution proceeds in a cumulative fashion which makes it culturally embedded and depends on cultural tools like language and codification. Thus ethnomathematics' adopts a post-structuralist cognitive psychology orientation on mathematics and mathematics education.

Another ethnomathematical challenge to mainstream cognitive psychological perspectives comes from the discourse perspective on mathematics learning. This perspective sees mathematics as a discourse, as a "special form of semiotic activity that includes all forms of discursive acts including language use carried out in a particular context" (Dorfler 2000 quoted in Panda P.360).[39] One learns mathematics by participating in this discourse. Since discourse is intimately related to the culture of the particular community, the context of mathematics and its terms of references become important in any program of mathematics education.

Linguistic studies have also contributed to the growing body of ethnomathematical literature. The use of number words in different cultures and the underlying world view has been an important area of research in ethnomathematics (Ascher 1991, Zaslavsky 1973). Ethnomathematics conjoins language, culture and mathematics and thereby insists on the

[39]http://pdfdownloadsforfree.com/SAORA-CULTURE,-AS-IF-DISCOURSE-AND-MATHEMATICS-LEARNING Accessed on 13/03/2011.

inclusion of mathematics into multilingual and multicultural educational programs which usually overlook mathematics. These studies argue that cultural practices such as ethnomathematics cannot be separated from the language of that particular culture (Meaney et.al. 2008, Fischer and Perez).[40]

3.3.5 Ethnomathematics and Philosophy of Mathematics

Ethnomathematics literature is conspicuous about its neglect of the philosophical stance of ethnomathematics. Barring a few exceptions (Barton 1994, 1998 and Ferreira 2010) most of the literature engages with rhetoric or the political and pedagogical implications of the field without any serious reflection about the implications for philosophy of mathematics. However, as a theoretical position ethnomathematics adopts a perspective on the nature of mathematical knowledge that contradicts the traditional conception of mathematics and this has a bearing upon the philosophy of mathematics. This section attempts to trace the points where ethnomathematics intercepts the traditional philosophy of mathematics.

The Stanford Encyclopaedia of Philosophy maintains that philosophy of mathematics has a special place in philosophy of science[41]. This special status derives from the virtue of its subject matter, methods of investigation and the status of mathematical knowledge. Mathematics studies abstract entities where as natural sciences investigate objects 'located in time and space'. Natural sciences use inductive methods of reasoning while mathematical knowledge proceeds through deductive reasoning (ibid). The major questions in philosophy of mathematics can be seen as centered on this special nature of the mathematical activity. Ernest encapsulates these questions as "...what is the basis of mathematical knowledge? What is the nature of mathematical truth? What characterizes the truth of mathematics? What is the justification

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[40] http://dg.icme11.org/document/get/310 Accessed on 13/03/2011.
[41] Horten, Leon *Philosophy of Mathematics'* http://plato.stanford.edu/entries/philosophy-mathematics/ Accessed on 17/03/11.

for this assertion? Why are the truths of mathematics necessary truth?" (1991 p3). Ethnomathematics can be seen as impinging on each of these questions. But before taking up that discussion it is worthwhile to have a glimpse of how various episodes in philosophy of mathematics have represented these concerns.

Until the late 19th century the dominant view in philosophy of mathematics was realism. Realism implies that mathematical entities are objective, abstract entities that inhabit an ideal realm and mathematical activity is seen as an attempt to come to terms with this ideal world. This view is usually traced back to Plato's conception of the world as two distinct realms - the world of ideas and world of things (Barton 1994). Mathematics inhabits the world of ideas and thus transcends the world of things (ibid). This implies that mathematical knowledge is an *a priori* knowledge- knowledge which is asserted on the basis of reason and not observation (Ernest 1991).

By the early 20th century the Platonistic view of mathematical reality gave way to a more empirical understanding and "three non- platonistic accounts of mathematics were developed- logicism, formalism and intutionism"[42]. These three schools of thought conceive mathematics as a product of construction rather than as an entity independent of human intervention. This change in perception of mathematical entity brought about a change in the philosophy of mathematics oriented more towards understanding the basis of mathematical knowledge. The major concern shifted from "...what is mathematics? To how can we be sure about mathematical truths?" (Tymoczko 1986 p.xiv quoted in Barton 1994 p.157).

Logicism attempts to ground the foundations of mathematics in logic. Developed by Frege, Russell, Whitehead and later by Carnap, the logicist program holds that, "all the concepts of mathematics can ultimately be

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[42] Horten, Leon *Philosophy of Mathematics'* http://plato.stanford.edu/entries/philosophy-mathematics/ Accessed on 17/03/11.

reduced to logical concepts...[and] all mathematical truths can be proved from the axioms and rules of inferences of logic alone" (Ernest 1998 pp.15-16). The formalist program was "based on the idea that mathematics was a formal system of symbols and axioms manipulated according to rules of logic" (Barton 1994 p.159). Hilbert, Neumann and Curry were the major proponents of the program.

Intuitionism searched for the foundations of mathematics "...[in] a number of universal mind given categories of thought including space and time" (Ernest 1998 p.20). Intuitionism is developed as a philosophy of mathematics in the writings of Brouwer and holds that mathematics consists of mental constructions. "The central idea is that mathematics originates and takes place in the human mind, and the mind recognizes basic, clear intuitions including the integers and events in time sequences. These intuitions are independent of experience, of language, and of the real world" (Barton 1994 p.158).

Barton (1994) argues that realism and foundationalist philosophy of science does not provide enough scope for a philosophy of ethnomathematics for all these schools of thought are based on the assumption of the universality and absolute nature of mathematical truth. Ethnomathematics on the other hand entails cultural relativism.

On the other hand the neo-realist argument developed in the writings of Quine and Putnam maintains that the existence of mathematical objects is indispensable for understanding the world. This implies that mathematics is justified only in application and implies that mathematical knowledge belongs to the realm of the "...as a posteriori; and liable to revision' (p.160). Godel's argument differs from that of Quine/Putnam for it draws on a distinction between different kinds of mathematical concepts. In Barton's words: "elementary mathematical concept are justified by intuition and more complex theoretical ones are justified by their consequences, i.e. they 'work' in physical theories' (p.161). "Neo-realism at first glance provides an opening for a relativist basis for cultural mathematics because, although the ontology is absolute, the epistemology could be relativist" (ibid). In other words neo-realism provides a scope for different understanding of the mathematical world which is consistent with other philosophies of science that subscribe to an epistemological relativism without abandoning ontology or lapsing into ontological relativism.

Barton also analyses the works of some of the twentieth century philosophers of mathematics. These philosophers Lakatos, Tymoczko, Davis and Hersh, Kitcher, Wittgenstien and Ernest among others can be broadly clubbed together under the philosophical position called fallibilism (Ernest 1998). Kitcher and Aspray (1988) refer to the group as the 'maverick' tradition in philosophy of science who seek to reconceptualize the traditional philosophy of mathematics (in Ernest 1998 p.xii). Fallibilism is the school of philosophy of mathematics that maintains that mathematical knowledge is not absolute but fallible, it is not a priori but based on the empirical (Ernest 1998). This implies that philosophy of mathematics focuses on the mathematics as it is practiced by mathematicians rather than reflecting on the status of the object of their work. Understanding mathematics in practice would mean that philosophy of mathematics provides space for a discussion of mathematics in its relation to other similar pursuits like science raises the question of relativism (Barton 1994).

The fallibilist philosophy of knowledge adopts a descriptive perspective as against the prescriptive role assumed by the traditional philosophy of mathematics. Traditional philosophy of science maintains a distinction between context of discovery and context of justification. It is assumed that context of discovery is not the subject of philosophical reflection but a subject of psychology or history of mathematics. The fallibistic position on the other hand argues that the context of discovery and the context of justification are inseparable. It is argued that like context of discovery, context of justification is not amenable to exposition only through logical inferences. The Lakatosian extension of fallibilism from philosophy of science to the philosophy of mathematics draws upon the resources of the history of mathematics . Thus the fallibilism in the philosophy of mathematics broadens its scope to include "mathematical knowledge, theories, object of mathematics, its application, mathematical practice and learning of mathematics" (Ernest 1988 pp.56-57). Ernest observes that this change in the conceptualization of philosophy of mathematics is a cumulative product of the sociological, historical, psychological and anthropological works on the nature of mathematics.

Fallibilsm by holding mathematical knowledge as fallible leaves open the possibility of simultaneous existence of different mathematical cultures. By incorporating mathematical practices in the philosophical reflection on mathematical knowledge fallibilism maintains the possibility of opening up the discussion on ethnomathematics. However, Barton argues that fallibilism fails to explain relativism in the context of encounter of two different mathematical conceptions. He argues that fallibilism is directed to theories and conceptions that have not been falsified (p.170) and history shows that this encounter always benefits the dominant discovery in the case of mathematics, the European conception of mathematics. Barton also criticizes that fallibilist position neglects historical relativism, he explains that "There is no way of knowing what theory of mathematics we may now have if the historical progress of mathematics had been otherwise, nor is there a way of knowing whether the hypothetical theory would be more comprehensive, more sophisticated, more applicable..."(ibid).

Attempts have been underway to search for other possible philosophical genealoges for ethnomathematics in the writings of Bachelard, Lakatos, Kitcher (D'Ambrosio 1987) and Wittgenstein (Barton 1994). These philosophers by analysing mathematics as a practice provide scope for reflexive and contextual understanding of mathematical production and provides vantage points for a philosophy of ethnomathematics. Barton (1994, 1998) also suggests an alternative system to understand mathematics as he feels that the current definition and understanding of mathematics restricts the scope for a cultural explanation of the system of knowledge and thus restricts the scope of philosophical reflection. He proposes a QRS (Quantity-

Relationship- Space) system that enables an understanding of mathematics as emanating from practice.[43]

It is not the purpose of this discussion to arrive at a particular position in philosophy of mathematics that is consistent with the ethnomathematical perspective. The issue of concern is where and how ethnomathematics might inform the philosophy of mathematics. Ethnomathematics as a field that claims to have implications for understanding the process of knowledge production and organisation demands a philosophy that engages with the variety of knowledge systems that are perceived as existing simultaneously without invoking a judgment on the basis of any predetermined value system. (Mathematical) knowledge production is seen as an activity that is contextual and historical. Ferreira (2010) remarks that ethnomathematics calls for a philosophical reflection on the issues of cultural encounter and alterity.

Understanding the philosophical discussion entailed by ethnomathematics is not only important to locate ethnomathematics in philosophy of mathematics, but it also sheds light on the dynamics of power at play in the field. Philosophy of mathematics has traditionally performed a prescriptive function thereby defining what mathematics is and explaining the properties of mathematical objects. Any prospective change in the conceptualization of mathematics thus has to engage in a dialogue with philosophy of mathematics more than anything else (Barton 2010). Ethnomathematics has risked its legitimacy as an alternative perspective by undermining the philosophical discussion.

But here it should also be noted that as Foucault (1980) suggests appealing to the dominant discourse in search of legitimacy is tantamount to accepting that dominance. But the dynamics of the field as Bourdieu suggests is determined by the structure of the distribution of scientific capital. And any attempt to alter the structure of the relationship in a field should aim at challenging the

[43] See section 2.7 for a more elaborate discussion of QRS system proposed by Barton.

monopoly of scientific authority which is again determined by the habitus of the field.

The foregoing section tried to understand the disciplinary and cognitive dynamics of the field of ethnomathematics. It can be inferred that the methodological and theoretical premises that underlie ethnomathematics cuts across various disciplines. The following section focus on the institutional aspects of the field. The formation of International Study Group on Ethnomathematics provided a great impetus to the development of the field. As most such societies do it helped consolidate the field and served to chart the direction for further development. It would be worthwhile to explore the various strategies and negotiations led by this organization that led to such rapid expansion of the field.

3.4 Institutional Dynamics of Ethnomathematics

An exhaustive sociology of ideas (Collins 1998) is incomplete without a sociological understanding of the group that produces it. The legacy of Collins and Bourdieu and others enables an understanding of academic communities as social groups. Collins proposes that an understanding of the inner dynamics and rituals taking place as part of these networks leads to an explanation of ideas and changes in them. Bourdieu gives us insights into the working of disciplinary associations. He comments that "a disciplinary association will help to sustain, within the disciplinary field, the functions of something like a community, managing part of the commons and relying on common interests, the common culture, in order to function" (2001 p.46)

Institutional visibility is an important factor in the development of any field. "It is agreed that a new academic field is established once it has considerable research production and publications, an organized community, a journal and regular courses, seminars, conferences and congresses" (D'Ambrosio 2004 p.8). The first major institutional recognition of the field of ethnomathematics came with the plenary lecture delivered by D'Ambrosio at International Congress on Mathematic Education in 1984. D'Ambrosio (1999) sees it as "the necessary academic opportunity to establish ethnomathematics as a legitimate research field" (pp.52-53). According to him, this was significant in bringing recognition to the area which later flourished with the formation of ISGEm in the following year.

Major debates on ethnomathematics in journals like *For the Learning of Mathematics*, *Educational Studies in Mathematics and ZDM* asserted the growing presence of the field. *For the Learning of Mathematics* brought out a special issue on *Ethnomathematics- in Mathematics Education* in 1994, edited by Maria Ascher and D'Ambrosio. The *Chronicle of Higher Education* also had opened a debate on ethnomathematics on its website in the year 2000 (D'Ambrosio 2004) Dissertations related to ethnomathematics are also being produced in the departments of mathematics education in various countries. Courses are also offered on ethnomathematics. The inclusion of ethnomathematics as the sub area 0IA 07 (sub area of history and biography) in the Mathematics Subject Classification of 1991 was major recognition for the field of ethnomathematics.

There are two referents of legitimacy of an academic field. One reference is its subject, methodology and other features that define and distinguishes it from other similar fields of study. The second reference is to 'scientific competence' (Bourdieu 1975), "the social process and technical capacity to act and speak legitimately in the field" (p.19). In this sense, the field of ethnomathematics has to be put in the context of a larger academic field. The discussion that follows tries to focus on negotiations and strategies followed by ethnomathematicians to establish its identity in the larger territory of academic knowledge. It should be underlined at the outset that all strategies are both political and epistemological (ibid).

The International Study Group on Ethnomathematics was instrumental in establishing the field of ethnomathematics. ISGEm was formed in 1985, at the

NCTM (National Council of Teachers Mathematics) annual meeting in San Antonio. It was meant to serve as a 'vehicle for communication of thoughts and projects on ethnomathematics' (Vol.1. No.1) provided a platform for sharing thoughts and projects on ethnomathematics and served as a site for negotiations and strategies that gave shape and form to the newly emerging field. ISGEm publishes a biannual newsletter which includes everything that would promote the interest of the field from research papers and book reviews to bibliographic information. A brief survey of this newsletter will give us an idea of the epistemological and political conflict in which ethnomathematics is engrossed.

An issue of the newsletter raised the following concerns: "One of the stated objectives of this newsletter is to carry a dialogue concerning just what is ethnomathematics?" (Vol. 9 1994). This objective was served since the first issue of the newsletter, which began with an article titled 'Ethnomathematics, what it might be?" It defined ethnomathematics at various levels. "At one level, it is what might be called 'math in the environment' or 'math in the community'. At another level, ethnomathematics is the particular (and perhaps peculiar) way that specific cultural groups go about the tactics of learning, ordering, counting and measuring" (Vol.1.No.1 1985). Mathematics and ethno were conceptualized in broad terms and D'Ambrosio's approach to explore the underlying structures of knowledge was put forward as a feature of ethnomathematics that distinguishes it from anthropological research on mathematics. It is interesting to note that in volume 3, number 1 of the newsletter published in 1987, the same article was republished but with comments from D'Ambrosio. This was meant to clean the air because it was pointed out that ethnomathematics is being equated to the mathematics of primitive people. D'Ambrosio refers to the history of science and mathematics to explain the underlying conflict in defining the term 'ethno'. He called for a broader conceptualization of the term ethno and asserted that,

> "There is an ethnomathematics of a certain age group of children in a certain neighborhood as well as ethnomathematics of nuclear

> physicists and so on. We are looking for a new paradigm which would bring us, through an undefined, unformalized and unmodified approach to mathematics education closer to dealing with really real problems such as those posed to us by modern society" (Vol.3 No.1 1987)

Across volumes, the newsletter attempts to define and explain ethnomathematics. Though a succinct definition is not always offered scholars are urged to carry forward the dialogue and it is expected that a more precise definition will evolve in the course of time. While deliberating on definitions of ethnomathematics, Luis Ortiz-Franco (1989 vol.4. no.2) observes that 'the history of humanity is replete with examples of intellectual endeavors which have taken much time to define'. Indeed, arriving at a definition for a field, especially for one with such multifaceted implications is not a onetime affair. The attempt here is to capture and analyze some moments of this ongoing process. The newsletter was thus the medium through which the contours of the field were maintained and expanded, with the inaugurators of the field playing the role of gate-keepers-the republication and clarification of D'Ambrosio could be interpreted in this light.

A discussion on the name of the organization also sprang up in one of the volumes. There again the prefix ethno was seen as problematic. Numerous alternatives were suggested like Meaningful Mathematics, Environmental Mathematics, Ethical Mathematics, Contextual Mathematics and many more. Similar discussion also take place at annual ISGEm, business meetings and research pre-sessions at the NCTM meetings. Paper presentations, lectures and panel discussions are held to explore and define ethnomathematics from various perspectives - given the emergent character of the field, most of the work in the field is an attempt to define and describe the field, its subject, methodology and potentials. Articles published in the newsletters explored theoretical, methodological and pedagogical issues related to ethnomathematics. Ethnomathematical sessions at conference like ICME also feature similar discussions.

The ISGEm constitution Article II, points out the purpose of the study group: "the organization shall be to encourage and maintain interest in the teaching and learning of mathematics in cultural context and to promote professional growth, fellowship and communication among its members" (Vol. 6. No.1 1995). ISGEm newsletters give us an idea of how meticulously these tasks were carried out. The newsletter has a section called *have you seen* which introduces the recent work on ethnomathematics to the readership. Apart from this, there is an annotated bibliography in every issue which acts as a resource pool for new researchers. Articles related to ethnomathematics from across the globe are also published. Along with this, the section *Member Projects*, introduces the new members to the group with a description of their ethnomathematical works. Plans were also worked out for creating a documentation centre for ethnomathematics. There are surveys of the thesis and dissertations produced in the area of ethnomathematics and every issue has a report on research in ethnomathematics which is basically a survey of the various works in different regions.

In the section on *upcoming events* the Newsletter provides information regarding various conferences related to ethnomathematics. Most of such listed conferences were on mathematics education although it also includes the conference and meetings of the American Association of Advancement of Science, African Mathematical Union Commission on the History of Maths in Africa etc. Members are urged to participate in these conferences. Subsequent issues of the newsletter contain reports on such conferences, where ethnomathematics was discussed. For instance, the VII Inter-American Conference on Mathematics Education held in Santo Domingo, the Dominican Republic 1987, was reported thus in the newsletter (Vol. 3 No.1 1987).

> "While the term ethnomathematics appeared in the title of only two presentations, the concept was often using in both and spirit. Two of the key note speakers, U D'Ambrosio of Brazil and Lelis Paez of Venezuela, both stressed the importance of cultural dynamics of mathematics education. A panel discussed the integration of the socio-

cultural text into the teaching of mathematics. The panel on how to develop student problem solving abilities also had much to say about the socio-cultural context of problem and problem solving. A working group formed on mathematics and reality probably has much in common with ethnomathematics"

These quotations help us to glean how the ethnomathematics community strategizes the struggle for a space in the academic field. A reference to the Newsletter Vol. 9, No.2 published in July 1994, will bring out this point more vividly. While planning for participation at the ICME, the newsletter asserts that:

"we would like a strong presence in Seville, Spain in 1996. In 1992, we had a Working Group and a Study Group. For 1996, we need to have our own identity. Ideas are needed, suggestions for ICME 8, 1996 are

- A major speech by a well known mathematician about ethnomathematics.
- A session on urgent research into ethnomathematics.
- Speakers from different counties on different aspects of ethnomathematics.
- Poster session"

These demands have to be seen part of the political struggle for legitimacy and grounded in an attempt to establish a disciplinary identity. One of the first proposals at ISGEm was to seek affiliation with National Council of Teachers of Mathematics (NCTM) and the International Congress of Mathematics Educators (ICME). It also extended its links to other groups whenever possible. Thus it had links with organizations like the Humanist Mathematic Network, Critical Math Network, International Study Group on Relations between History and Pedagogy of Mathematics (described as the organizational cousin of ISGEm). Links with other organizations and participation at various conferences increased the scope and base of ethnomathematics as a field.

The ISGEm also has a publicity committee. It would not be wrong to say that this worked as a strategizing committee. A glimpse of the report of the publicity committee published in the newsletter speaks more about this.

> "....would like us to ask all ISGEm members to assist with publicity by mentioning the organization and its address-any time they make a presentation in schools, PTAS, university meetings, conferences, radio interviews etc. .... We should urge anyone who writes on ethnomathematical topics for publication to also mention the organization in the article or as note at the end........ISGEm members who are participating in or (better) helping to organize state or regional NCTM, MAA, SSMA, etc. meeting should see if formal or informal ISGEm gatherings can be added to the program" (Vol.8 No.2 1993).

The newsletter was translated into several languages and the expansion of the field within a short period of time was tremendous. Going by the list of ISGEm newsletter distributors, it can be inferred that ISGEm which had a reach in 6 nations in 1992, has expanded to reach almost 20 nations by 1998. This enormous spread in just six years is the result of the efforts by ISGEm to establish ethnomathematics as a field of research. This expansion of the field, led to the formation of regional chapters of ISGEm, through a constitutional amendment in 1996. These chapters have an organizational structure similar to that of ISGEm. The major purpose of the chapters was to coordinate the activities in their region. ISGEm website has links to three regional chapters-North America, South Africa and Brazil. The North American chapter of the study group is affiliated to NCTM (D'Ambrosio 1999). It also publishes its own newsletter and a peer reviewed journal named *Journal of Mathematics and Culture.*

In a globalised world characterized by an information society (Castells 1996) the flow of ideas across the global landscapes (Appadurai 1996) gains a momentum and volume hitherto unseen. This massive flow of communication has also influenced academic networks. ISGEM also made its presence in the virtual world, with the inauguration of its website in 1996.[44] An electronic discussion group was also started in 1998. Currently, the website is available in four languages: English, Italian, Spanish and Portuguese. The website provides links to several articles as well as to an ethnomathematics digital library. The newsletter and website also give information on the various courses on ethnomathematics being offered in different parts of the world. The website even provides a detailed syllabus for each of these courses. A data base of software and video resources related to ethnomathematics is also available on the website. An electronis journal Mathematics Anthropology and Cultural Theory was also started (D'Ambrosio 2000).[45]

The content and the form of newsletter and website become important because they serve as the mouthpiece of the organization. The ISGEm newsletter and website was basically meant to serve as a vehicle for the communication of the idea of ethnomathematics and thus to mark its academic presence. An elaborate bibliography and discussion of ongoing ethnomathematical projects meant to serve as a resource base for new entrants in the field. It is also important to note that the newsletter vol.17, No.1, published in 2003 has a different organization of the contents page. Sections like *have you seen, member projects* and *annotated bibliography* no longer form part of the later newsletters. This can be interpreted as a sign that the discipline has attained some stability and a captive group of readers and researchers-the community is now in place.

Thus the institutional and political strategies adopted by ISGEm can be seen as instrumental in bringing together research from around the globe into a

[4444] http://www.rpi.edu/~eglash/isgem.htm.

[45] http://www.SBBay.org/MACT.

common platform, where they can share their works as well as get to know about similar attempts taking place in other parts of the world. A new direction was charted for these researches by linking them to the teaching and learning of mathematics. It is interesting to note that Zaslavsky and Marcia Ascher-whose work had a great influence on the subsequent development of the field-came to know about the field through ISGEm newsletters.

In order to organize the vast body of research work done on the socio-cultural aspects of mathematics in different parts of the world, ISGEm formed four special interest groups-

a) Research in culturally diverse environments.

b) Out of school applications.

c) Curriculum and classroom applications.

d) Theoretical perspectives.

Coordinators were appointed for each of these groups and these four major areas were used as a referent for planning sessions at various conferences.

International Study Group on Ethnomathematics also organizes conferences. These conferences have to be understood as rituals (Collins 1998) that bring and bind researchers together in to a community. With the first conference held in 1998 in Granada, Spain, D'Ambrosio declared that the field had reached adulthood (1999). The Second International Conference on Ethnomathematics (ICEm II) was organized in Ouro Preto, Brazil followed by the third conference in Aukland, New Zealand in 2006 and the fourth one in Maryland, USA in 2010. The next ICEm is set to be held at Mozambique in Africa in 2014.

The foregoing analysis is based on issues of the newsletter published until 1998 only. This is a serious limitation for we cannot trace the entire course of this process and do not know the moment and momentum of this negotiation at present, after more than two decades of formation of ISGEm. Nevertheless, to trace the major trends in these negotiations, it would not be wrong to observe that at least in the early stages of development of the field ethnomathematics was more in interaction with mathematics education than mathematics. Though there have been discussions on the philosophical and theoretical implication of ethnomathematics on mathematics and there were suggestions to make ethnomathematics a sub discipline of mathematics (Ascher, 1985), if we try to map ethnomathematics on the larger plane of disciplinary activities and institutions, we see the contours running through concerned areas of mathematics education.

Since the inauguration of the field (D'Ambrosio' lecture at ICME 5, 1984) ethnomathematics has been associated with mathematics education. The formation of ISGEm at the NCTM also leads us to understand that, mathematics education has been a fertile field for the emergence and development of ethnomathematics, even though D'Ambrosio projected ethnomathematics as a larger research program in the production, dissemination and organization of knowledge, he traced its roots to the pedagogical and curricular concerns raised in the context of mathematics education.

The institutional presence of ethnomathematics can also be traced to the departments of mathematics education. This is also true in terms of the intellectual location of major thinkers of the field. Most of the empirical research in the field is done in the area of mathematics education. The ISGEm newsletter gives more evidence for this inclination to and affiliation with mathematics education. The ISGEm constitution states that the organization was formed to further the research area of mathematics learning and teaching. Even at the first meeting of ISGEm it was decided that a special session on ethnomathematics will be held at the NCTM meetings and at the 6th Inter-American Mathematics Education Conference 1985, set in Mexico. This was carried forward with several other conferences mostly on mathematics education.

Due to the unavailability of material of the society after 1998 we cannot infer any change in the emphasis or direction of research within the field. However, there is enough reason to speculate a fluctuating emphasis on mathematics education and historical and philosophical aspects mathematics as the field is growing. A glimpse of this movement can be seen in the work of the prominent authors in the field which is already discussed in the previous chapter. A review of the major themes at ISGEm conferences helps to perceive this shift more clearly. The major objective of 1st ICEm held in 1998 at Granada was the expansion of the field of ethnomathematics by enabling cross cultural communication and too "provide an atmosphere of cordiality among teachers/researchers from all countries, who are interested in this area" (conference 2nd announcement letter).[46] It also aimed to "share educational experiences and curriculum development proposals on mathematics teaching that are based on social and cultural environments". ICEm II, held at Brazil in 2002 exhibited a growing concern towards philosophical and theoretical aspects of ethnomathematics though the major thrust was still on mathematics teaching and learning. The conference began with a discussion of *Paulo Freire's Contribution to the Epistemology of Ethnomathematics* (Vol.17 No.1 2003) and one of the four major lectures delivered was on *philosophy of education and ethnomathematics perspective.* While reflecting on the ICEm-III held at Brazil, (Barton et.al. 2006) it was observed that "there has been a clear move towards educational issues, and a small shift towards theoretical issues. There are a lower proportion of anthropological studies of specific group knowledge" (P.22). Further at ICEm IV held in 2010, major debates were structured around the implications of ethnomathematics-for mathematics education as well as the larger project of democracy and peace envisaged by D'Ambrosio.

Ethnomathematics as a field has a very short history. But the strides it has made within this short period are remarkable. The role of ISGEm and its newsletter, website and conferences have played a major role in the expansion

[46] http://www.ugr.es/~oliveras/ICEM1IN.htm Accessed on 12/12/2010.

of the field. In other words, these have been major instruments/techniques in the struggle for a legitimate space and identity for ethnomathematics as a field. Even though ethnomathematics may have established itself as an academic field its epistemological niche is yet uncertain and unclear. Its identity as a subfield of mathematics or mathematics education is still under negotiation.

However it is acknowledged that the chapter fails to give a detail analysis of the expansion of the field, which could have been traced with the help of quantitative measures like time series data on the number of members, number of journals, number of publications distributed across journals etc. It also falls short, in analyzing the internal structure of the International Study Group on Ethnomathematics which would have brought out the internal political/social negotiations into light.

Chapter 4

Implications of Ethnomathematics

The thrust of the previous chapters was to elucidate the nature of the field of ethnomathematics. The disciplinary and philosophical implications of ethnomathematics were discussed. Ethnomathematics calls for perspectival change in understanding the nature and polemics of mathematics as well as puts forward a new proposal for the historiography of science and technology. This chapter undertakes a critical appraisal of the potential of ethnomathematics to usher pedagogical and political reform. Fragments of the pedagogical program of ethnomathematics can be discerned throughout the foregoing discussion. This chapter attempts to recapitulate those points in a more focussed discussion on the pedagogical praxis of ethnomathematics. The discussion is organised into two broad sections. The first section reflects on the major themes, issues and debates related to the pedagogical program of ethnomathematics. The second deals with the issues implied in ethnomathematics curriculum development. The discussion leads to an appraisal of the implications of ethnomathematics to the field of mathematics education.

4.1 Themes, Issues and Debates

The educational domain of ethnomathematics is the area where all the sub-domains of history, anthropology, sociology, philosophy and cognitive studies converge (Francois and Kerkhove 2010, Skovomose and Vithal 1997). For many scholars in the field ethnomathematics is an educational movement (Knijnik 1993). The pedagogical proposal of ethnomathematics has to be understood as a corollary of the relationship between mathematics and culture envisaged by ethnomathematics. Mathematics is seen as a cultural activity rather than as an abstract context free enterprise. Ethnomathematics as a pedagogical proposal seeks to make the cultural embeddedness of mathematics a basis for the curriculum development and pedagogy in mathematics education which is otherwise based on a 'static representation of learning' (Boaler 1993). The major issues and debates regarding the pedagogical praxis of ethnomathematics have to be located in the lager theme of distinction between academic mathematics and ethnomathematics.

4.1.1 Ethnomathematics and Academic Mathematics

A reflection of the relationship between these two distinct but interrelated bodies of knowledge and the kinds of interactions possible between them opens up the discussion of the pedagogical potential of ethnomathematics.

The distinction between academic mathematics and ethnomathematics is represented as the difference between 'M' and 'm' (Bishop 1988, Barton 1994, Pinxten 1994). M refers to the mathematics which is practiced as a scientific, professional discipline, where as 'm' denotes the "set of skills and procedures for counting, measuring and the like, that a group or an ordinary individual knows and uses in life" (Pinxten 1994 p.23). There are overlaps between M and m, though the nature of this relationship is yet to be explored fully (Bishop 1994). The efforts for incorporating ethnomathematics into mathematics education have to be understood in terms of this relationship-as an effort to navigate the link between 'm' and 'M'.

For D'Ambrosio (1985) the distinction between ethnomathematics and academic mathematics lies in the structure and organization of knowledge. He holds that ethnomathematics refers to practices that do not reach the level of mathematization. Mathematization is the process through which practices and ideas in a society are expropriated into the fold of formalized knowledge by those who hold the power to define knowledge. There is a "time lag between the appearance of new ideas in mathematics outside the circle of its practitioners and the recognition of these ideas as 'theorizable' into mathematics, endowed with appropriate codes of discipline until the expropriation of the idea and its formalization as mathematics" (ibid p.47). Many ideas that are present in cultural practices are very often not formalized. However the practices continue in the community in which it developed although the movement towards theorization is stalled. According to D'Ambrosio ethnomathematics lies at this level. There are practices that do not reach mathematization.

D'Ambrosio (1985) traces the development of this distinction between scholarly mathematics and practical mathematics through the history of mathematics education. He explains that this distinction was present in the Egyptian origins of mathematics and was carried on to the Greek period and followed by the Romans too. Scholarly mathematics was seen as the privilege of a select few and practical mathematics was meant for the masses (Plato in D'Ambrosio 1985, p.44). The middle ages witnessed a convergence of this distinction especially in the field of geometry and arithmetic. This trend followed during the Renaissance with the consequent changes in labor structure. The industrial revolution encouraged the approximation of practical mathematics to scholarly mathematics.

These trends are reflected in mathematics education as well. Mathematics education assumed a new socio- economic role. Along with maintaining the social structure by sustaining the aristocracy mathematics was assigned a productive role. This led to mathematics being "adapted and given a place as 'scholarly practical' mathematics" (D'Ambrosio 1985, p.45), that refers to the practical mathematics that was appropriated as scholarly mathematics.

For Daniel Orey and Milton Rosa (2007) the distinction between 'modern Western academic mathematics' and ethnomathematics is based on the values that each of these systems implicate. According to them ideas of dominance, control, arrogance and cultural hegemony characterise western mathematics, whereas the "ethnomathematics program considers a concept of mathematics which includes a critical, moral, holistic, and global perspectives" (p.S10).

As it emerges for the discussion above, the major distinction between academic mathematics and ethnomathematics is traced in the organization of knowledge and the value it entails. The major issues that surface in the discussion of pedagogical program of ethnomathematics implies this distinction and for the sake of brevity can be encapsulated under the headings of- 1.Reification and Embeddedness and 2.Politics.

4.1.2 Reification and Embeddedness

The universal nature of mathematical truths leads to a presumed universality of mathematical knowledge and practice. These presumptions underlie the standard mathematics curriculum, which does not appeal to the learner's cultural background and conceptual baggage and hence fails to attract the interest and attention of the students. This problem becomes more complicated in the Third World where curriculum is imported from the First World in the guise of transfer of knowledge. This is also endorsed by a philosophical attitude. The absolutist philosophy of mathematics was based on the apriori nature of mathematical truth which was conceived of as following a logical track of development without reference to empirical reality. Mathematics education based on this absolutist and foundationalist philosophy, also conceives of education of mathematics as moving from one logical stage to another. The cultural aspects of mathematics and the socio-cultural and psychological circumstances of the learner were left out as unimportant (Pinxten 1994). The pedagogical praxis of ethnomathematics has to be located in this problematic of politics and philosophy of knowledge and learning.

Ethnomathematics is incorporated into mathematics education for a number of reasons that are political, linguistic, mathematical, motivational and educational (Barton 2004). Concerns emerging from the perceived difficultly of mathematics as a school subject is germane to the ethnomathematical perspective on mathematics education. Different concerns like the lack of interest of the students' in the subject, its apparent status as the most difficult subject in the school, decreasing number of students who take mathematics for higher education, failure of students from a particular cultural group etc. distill down to one reason-the alienation of the learner from mathematics (as a school subject). This alienation is mainly traced to the decontextualised, abstract and utilitarian curriculum and the impersonal and unreflective pedagogy that fails to link mathematics in to the student's life world and hence fails to make sense to them. As an antidote ethnomathematics calls for a more contextual, value based, contemporary and rights based education that implies a broader conception of mathematics and mathematics education. It calls for an overall change in the perspective and agenda of mathematics education.

The *cultural alienation* (Eglash 1997) thesis has many takers in the field of mathematics education. Alan Bishop (1994) puts forward a *cultural-conflict* model to further explain the cultural alienation thesis. He argues that because of the difference between the culture inside the school and outside the school, the learner is in a situation of perpetual cultural conflict. The impersonal nature of mathematics learning also adds to the alienation of the learner. Impersonal learning means that the "learner is conceived of as being independent of the person of the learner. That is, what is considered important is that the learner learns mathematics not that the learner strives for some personal meanings from mathematics education"(Bishop 1991 p.9). Cultural alienation thus results in learning experience that result in "meaninglessness, the rote-learning syndrome, the general attitude of irrelevance and purposelessness" (Bishop 1988 p.189). The recognition of this conflict situation is a prerequisite to address the educational failure and difficulty that characterize mathematics education. This requires a paradigm change in the understanding of the possibility and potential of interaction between mathematics and culture.

Ethnomathematics conceives of mathematics as a cultural product and proposes to bring this cultural connection into the classroom. In other words, ethnomathematics proposes an investigation into the learner's background to find out examples of mathematical ideas and practices that can be tapped for enabling a creative and interactive pedagogy of mathematics education that ethnomathematics implies. Thus appealing to the learner's cultural background helps to reduce situations of cultural conflicts in classroom and enhances learning.

According to D'Ambrosio (2000) the discussion on mathematics education revolves around the questions of why, what and how that implies the objectives, contents and methods of teaching mathematics. While the content and methods of mathematics education has been debated hotly and new and different paradigms suggested and rejected, the question of objectives have always been implicit or 'taken for granted'. Thus he argues the debate on mathematics education should begin with deciding upon the objective of mathematics education (ibid).

Bishop (1988) argues that the kind of mathematics education that a traditional mathematics curriculum entails does not teach mathematics but trains students to do mathematics without any engagement or reflection. He calls this *technique-oriented curriculum*. It is a "user's curriculum which purports to develop a comprehensive and wide ranging tool- kit for the user" (Bishop 1991 p.8). But given the nature of the job market which demands specific skills, even this tool kit becomes redundant because the worker is not allowed the freedom or creativity to experiment with these tools (ibid).

From an anthropological perspective Bishop reflects on objectives of mathematics education by proposing the concepts of *mathematical enculturation* and *mathematical acculturation*. Enculturation is the process through which the child is prepared for induction into the local culture. Acculturation on the other hand refers to the "induction of the person into a culture which is in some sense alien and different from that of their home background" (1988 p.187). Bishop argues this enculturation/ acculturation dichotomy becomes intricate in the case of mathematics education, because western mathematics which forms the basis of standard mathematics curriculum is an amalgam of various cultural traditions. So the enculturation function of a curriculum based on western mathematics becomes problematic. Bishop contends that the idea of mathematical enculturation depends on the degree of influence of western mathematics on a particular culture, the "greater the degree of influence, the more appropriate would be the idea of enculturation" (ibid. p.188). Whereas in the case of most of countries, especially in the third world countries, the standard mathematics curriculum and pedagogy can be seen as 'intentionally acculturative'. Apart from alienating the child form the process of learning, this perspective also reinforces the myth that these cultures are incapable of doing mathematics (Bishop 1994).

D'Ambrosio argues that every person (unschooled) in the society acquires some basic mathematical skills as part of socialization. D'Ambrosio (1985) calls it 'spontaneous matheracy'. An ethnomathematics curriculum builds on this spontaneous matheracy where as the traditional school mathematic destroys this ability by imposing alien conceptions and practices of mathematics. Ultimately the child ends up in a situation where the spontaneous matheracy is lost and academic mathematics is not imbibed either.

Ethnomathematics claims that its major focus is on the relevance of mathematics education in contemporary world. D'Ambrosio and Ascher (1994) notes that the mathematics curriculum does not correspond to the advancements in the discipline. They hold that a large part of mathematics curriculum is based on mathematics of the 17th and 18th century. Given the important role for mathematics and mathematicians in the future it is necessary that the curriculum is updated appropriately (D'Ambrosio 1990). Garii (2008) also argues the same. She observes that "semantically and practically, school and professional mathematics are often at odds with each other".[47] While professional mathematics is embedded in practice, contextualised and flexible, school mathematics emphasizes on strict algorithmic exercises and thus limits mathematical creativity. Hence

[47] http://dg.icme11.org/document/get/451 Accessed on 20/02/2011.

ethnomathematics argues for a more contemporary curriculum which is not based only on the aim of preparing students for secondary education-a system where the only emphasis is on the credentials in examination-but enables them to participate and engage in interaction with the world in which they live.

Alan Bishop (1990) identifies a cluster of three pairs of values each related to the ideological, attitudinal and sociological dimension of mathematics education. The ideological values are objectivism and rationalism. The attitudinal dimension includes control and prediction, where as the sociological dimension relates to openness and mystery (the unreasonable origin and uses of knowledge) (Francois and Kerkhone 2010). These values in various ways have held western mathematics at a higher pedestal in the knowledge hierarchy and also used to evaluate other knowledge claims. Paul Ernest (1991) also discusses such values engendered by mathematics education. As for the inherent values of mathematics, he has documented that 'abstract' is esteemed higher than 'concrete', 'formal' higher than 'informal', 'objective' higher than 'subjective', 'justification' higher than 'discovery', 'rationality' over 'intuition', 'reason' over 'emotion', 'general' over 'particular', 'theory' over 'practice', 'intellectual' over 'manual' etc. (Ernest 1991 p.259 quoted in Francois and Kerkhove 2010 p.145). The discussion on values in mathematics education, more than any other issue can be seen as directly invoking the distinction between ethnomathematics and academic mathematics. In fact the difference between these two bodies of knowledge has been inferred in terms of the values and attitudes they entail (Francois and Kerkhove 2010).

4.1.2.1 Aesthetics

One of the major concerns of ethnomathematics is the instrumentality of mathematics insinuated by the traditional mathematics curriculum. Traditional mathematics curriculum portrays the subject as an impersonal pursuit emphasising only on problem solving with mathematics. These problems are presented as abstract and decontextualised situation, demanding only an algorithm to find the right answer, without any reflection on its meaning. Mathematical problems by removing the context reduce real life situations to mere manipulations of numbers.[48] This preoccupation with commercial transactions in mathematics education reduces mathematics to the realm of trade and commerce and misses out on a larger universe of ideas that embed mathematics. D'Ambrosio and Ascher (1994) insist that mathematics is not only about survival but also about transcendence of human life and hence entails not only utility but aesthetics also. Conceived in this manner mathematics provides scope to include cultural practices such as basket making, weaving, tapestry, decorative motifs etc. in its ambit. However there are branches of academic mathematics that deals with aesthetic forms especially in geometry. Ethnomathematics in its attempt to highlight the mathematics in cultural practices pushes these branches in to oblivion.

4.1.3 Politics

The pedagogical project of ethnomathematics is equally a political project. For Orey and Rosa, ethnomathematics emerges from the "concerns for equity, equality and excellence in a context of diversity" (p.11). The discussion on the political aspects of ethnomathematics is divided into two sections–one that deals with emancipatory politics especially in the Third WSorld and a complementary section that highlights issues of multiculturalism in the context of gender, ethnicity and identity.

[48] It is also important to note that a large number of the mathematical word problems which are provided with an imagined situation deal with commercial transactions. Hence to claim that mathematics education presents itself in a value free context is a short-sighted one without paying attention to the subtleties of the process.

4.1.3.1 Emancipation

For D'Ambrosio, the major objective of teaching mathematics is to enable people with a critical and analytical power. As suggested D'Ambrosio envisages an important role for mathematics and mathematicians in achieving peace in a strife stricken world and in the moment towards a world without bigotry, hatred and arrogance. Ethnomathematics is hence a movement that expects to bring about a change in mathematical attitude by emphasising the diversity of world views and claims an equal epistemological status for them.

A similar idea underlies Zaslavsky's arguments. She argues that 'mathematics should be empowering'. Mathematics should empower student to perceive, analyze and take action on matters that are integrally related to their daily lives. Elaborating on the need to infuse ethnomathematical perspective into mathematics education, Zaslavsky (1991) argues that mathematics education should enable students to understand that ideas and practices they are learning are intimately connected to the needs of survival of human beings. Simply speaking of the 'Indo- Arabic' numerals or 'Roman' numerals does not tell students anything about their origin nor does it say anything about the development of mathematics.

D'Ambrosio's and Zaslavsky's argument on the emancipatory role of mathematics expands the scope of ethnomathematics beyond school mathematics learning. Mathematical learning is perceived as a broader process than that inferred by traditional mathematics education. School mathematics education is traditionally based on the aim of preparing students for higher education which then makes them capable to undertake the specialized roles demanded by the state and economy, in today's context, the knowledge economy. However, ethnomathematics takes a different line of argument. It is argued that mathematics education should focus on the "development for the majority of people of ability and a disposition to use mathematics as a critical tool" (Mukhopadhyay and Greer 2001 p.310). Developing this ability to think and act mathematically has been recognized as the role of education in future.

Thus ethnomathematics entails a broader concept of mathematical literacy- "...as an individual's capacity to identify and understand the role that mathematics plays in the world, to make well founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen" (Watanabe and Mc Gaw 2004 p.37 quoted in Francois and Kerkhove 2010 p.144).

4.1.3.2 Ethnomathematics in the Third World

The appeal of ethnomathematics to third world mathematics education has already been discussed briefly while discussing the history of mathematics and its relationship with ethnomathematics. This section attempts to elaborate on that discussion by raising certain issues that are important for a critical analysis for any educational praxis in the third world.

The use of the term 'third world' itself locates the discussion in a larger politics of world systems and insinuates the politics of cultural and knowledge production, not to mention the economic, social and nation-state politics that it implies. History and sociology of colonialism invites us to understand colonial encounter as a cultural project which had long lasting consequences for the colonized nations.

Gelsa Knijnik' (1993) argued that "pedagogical practice in mathematical education is fundamentally a political issue" (p.23), and explores the emanicipatory questions raised by ethnomathematics in the context of the third world. For Knijnik (1993), ethnomathematics is an educational movement and fundamentally political. Knijnik's conceptualization of the ethnomathematical approach speaks of the pedagogical and political role she envisages for ethnomathematics. Knijnik's position is similar to that Gerdes. In tune with Gerdes' unfreezing project, Knijnik's ethnomathematical approach "....tries to probe into and rescue popular mathematics"...... "it tries to decodify and understand it, giving the students the opportunity to become aware of the limitations of their methods and the reason why these methods, even without being exact, are utilized by subordinate rural groups" (p.28). She argues with Gerdes that this kind of cultural awareness will result in synthesis knowledge. This process of synthesis starts with popular knowledge, but transcends it.

Bishop (1990) argues that western mathematics was the most "powerful and secret weapon of western imperialism" (p.51). In the process of cultural imperialism, western mathematics had three major medicating agents which Bishop identifies as trade, administration and education. "In the field of trade and commerce, the western notions and standards, measures, units, numbers, currency and some geometric notions were imposed on the indigenous societies" (p.53). The indigenous notions were neglected and rejected as not useful enough for the trade requirement. Similarly in the area of administrations and governance, the indigenous systems failed to meet the needs to keep the statistics and details of the large number of people and commodities. New ways of classification and numeration were introduced. Bishop also argues that the 'language of hierarchy' that was introduced in the colonial societies was different from the indigenous linguistic cosmos. The same line of cultural imperialism followed in the area of education also. The western education system that was imposed on the colonies was meant to serve the needs of the colonial empires. The education in the colonies was structured on the basis of the curriculum in the home (Empire) nations. This curriculum was intentionally 'acculturative' aiming to inculcate western ways of life and thoughts and the enculturation of the learner was completely neglected.

The situation was worst in mathematics education. "At best, the mathematics curriculum of some of the schools was just laughably and pathetically inappropriate... At worst, the mathematics curriculum was abstract, irrelevant, selective and elitist..." (Bishop 1990 p.55). The idea of appropriateness was judged in terms of cultural transmission, in an education system which was meant to establish the 'symbolisations and structures' of the Empire on the colonial nations (ibid, Kumar 2005, Chakrabarty 2000).

This hegemony of western knowledge systems continued in colonial nations through the importing of the curriculum in the guise of the transfer of knowledge.[49] As a consequence the third world nations suffered the burden of a curriculum which did not correspond to the needs of their society. In the context of Africa, Zaslavsky writes that "their African schooling had informed them about ancient Greece and modern Europe, while African history and culture were not considered worthy of studies" (1994 p.4).

Krishna Kumar (2005) explains a similar situation. In India British introduced an 'appropriate' curriculum which gave importance to Western science, literature and philosophy which was in a stark contrast with the child's everyday reality. As a result the child became an alienated being in the system of education. The overwhelming presence of English (a foreign language) as the medium of instruction added to this alienation. The conflict resulted in the process where children learned all the 'facts' they were asked to by rote and did not express any enthusiasm for knowledge that arose in their mind. Ultimately the function of school became forcing the children to protect themselves through memorized reproduction of the subject, which they could not grasp and found meaningless.

The teacher too was alienated. Colonial rule made a drastic change in the role of teachers, as they could no longer decide on what to teach and how to teach. Traditional method lost its ground after the introduction of prescribed syllabi and textbooks. The teacher's status was diminished to such an extent that the profession could not engender any sense of security or self-confidence since the assessment of his/her capacity to carry out the work was controlled by the bureaucratic system and the devices of graded certificate of performance and payment by results (Kumar 2005).

Recent studies (Adam 2004) show that ethnomathematics can be a viable option for third world countries whose curriculum still lingers in the effects of the 'transmission of knowledge model. The incorporation of

[49] See section (introduction for a trajectory of this discourse).

ethnomathematical material and perspective in traditional mathematical material is supposed to enhance motivation and interests of the students and teachers. Adam's (2002), work in Maldives supports this hypothesis and Lipka's (2002) findings that student who learned in an ethnomathematical way performs better on conventional mathematics tests strengthens the argument (Adam et. al. 2003). Ethnomathematics is also seen as a powerful tool for national development (D'Ambrosio 1985) and cultural reconstruction (Gerdes 1981) in erstwhile colonial nations. Thus in the context of Third World countries ethnomathematics is an explicitly political issue intimately related to national pride, self respect, cultural dignity and definitely to the critical values of egalitarianism, critique and emancipation.

However, colonial encounter has to be understood as a process in which both the agents, the dominated and the dominant, take part in cultural production. Of course the power relations exist and the agency of the dominated itself is an interpellated one. But this creates a complex political and cultural reality that cannot be overlooked because it plays a very important role in the cultural production in colonial countries and is later reflected in the process of cultural reconstruction after the independence.

Kumar's (2005) thesis of the homonymous nature of the colonial and nationalist discourses of education in India asserts the point. He points to the need for a more complex understanding of the colonial encounter and the implicated role of education in it. In India, that the creation of a civil society based on the Victorian notions of rationality and morality was the core of colonial agenda (ibid). The main part of this agenda was the creation of an order in which education played a crucial role. The self perception of Indians which emanated from English education formed the basis of this civil society. But this transformation was not simplistic. The civil society thus formed had a very narrow base, mainly drawn from the upper caste and that too from major towns. Krishna Kumar argues that this policy of colonial education resulted in a situation where the relation between the educated few and the uneducated masses came to resemble the relation between the colonizer and the colonized.

This similitude in the colonial and nationalist thought influenced the further development of education throughout India.

Thus it seems that independence of the colonial nations does not amount to decolonization which is a more complex cultural and social process. The process of nation building has to be understood as a political process. Only variables change, equations remains the same-power/knowledge, dominant/ dominated and so on.

Krishna Kumar's analysis of education in India is a insightful study for any historical critique of the colonial education system. It also points towards the lacunae in the ethnomathematical literature, which fails to understand the process of colonial encounter from all sides. For instance in historical analysis of mathematics education in Mozambique, Gerdes (1981) insists that "to prevent African students from being alienated from mathematics-from experiencing mathematics as a rather strange, useless, and uninteresting subject, imported from outside Africa-the African mathematical heritage, traditions, and practices have to be 'embedded' or 'incorporated' into curriculum" (1993 p.18). However he fails to problematize the educational system after independence and takes nationalism and massification of education as inherently leading to democratization.

The argument that ethnomathematics helps in cultural reconstruction in erstwhile colonial nations needs to be qualified in the wake of this insight which reveals a more complex networks of power relations at various levels.

Moreover there is a need to problematize the very category of ethnic group. Studies point out that the formation of ethnic groups can also be a consequence of the restructuring of societies affected by colonialism (Kurien 1994). The rise of fundamentalisms in various forms and the movement to trace back and revive cultural heritages complicates the category of 'ethnic'. The appropriation and manipulation of Vedic mathematics by the Hindutva fundamentalists in India is a case in point (Nanda 2006). The attempt here is to stress the point that decolonization and cultural reconstruction are complex processes and to assume that an ethnomathematics curriculum will simply lead to cultural rebirth and emancipation will amount to miss out the nuances of the argument.

4.1.3.3 Gender, Ethnicity and Identity

Alan bishop while discussing the cultural conflicts in mathematics education refers to the UNESCO publication *Mathematics, Education, and Society* [Keitel, 1989]. This report of the Special Day's proceedings in ICME 6, demonstrates that among the groups for whom conflict with, and alienation from, school mathematics exists are:

- ethnic minority children in Westernised societies
- second language learners
- indigenous "minorities" in Westernised societies
- girls in many societies
- Western "colonial" students
- fundamental religious groups, often of a non-Christian nature
- children from lower-class and lower-caste families
- physically disadvantaged learners
- rural learners, particularly in Third World communities

As a cognitive movement ethnomathematics attempt to bring these sections of the population back into the gamut (mathematical) knowledge production and distribution. It raises issues like cognitive justice, right to cultural diversity and other political issues embedded in the knowledge politics of an increasingly globalizing society.

The political convictions of ethnomathematics derive from the presumption that the failures of students from these marginalised groups are a consequence of the culturally alienating curriculum imposed on them. Ethnomathematics argues that each of these groups has rich and diverse source of mathematical knowledge which is neglected under the ascendancy of western mathematics. An ethnomathematics based curriculum will serve to revive and reconstruct these capacities in these subjugated cultural groups and thereby enhance their self respect and dignity creating a confidence to act and think critically. An ethnomathematics program is based on the contention that "in attempts to renew education, making it clear that good minds are available in every sector of society, it is important to demonstrate the rationality of peasants, women, native Americans, blacks and others by showing they are also capable of doing mathematics" (D'Ambrosio 1997 p.16) Recognising and appreciating the mathematical ideas of these diverse cultural groups would mean a different conception of mathematics and the values it implies.

The changing demographic profile of the countries with increasing movements of people across borders and the flow of ideas (Appadurai 1996) also calls for a need to multiculturalise education. Although the multicultural movement in mathematics education has initiated changes in the curriculum, mathematics was not paid much attention to, perhaps because of its perception as a universal discipline. Ethnomathematics strongly argues for a multicultural approach to mathematics education which is important to define the role of mathematics and mathematicians in a global world.

The multiculturalist argument of ethnomathematics is largely based on a historical understanding of the development of mathematics and mathematics education. Ethnomathematics argues that a historical approach to mathematics (grounded in a new historiography) is a requisite in mathematics education, for mathematics is a cultural product and western mathematics is an amalgam of various cultural traditions. Emphasising this cumulative evolution of mathematics as a discipline will not only shed light on the contributions of diverse cultural traditions but also serves to raise the issue of politics of knowledge.

Zaslavsky writes, "they (American students) should know that a great deal of the mathematics that they learn in elementary and secondary school originated in Asia and Africa centuries before Europeans were aware of more than the most elementary aspects of mathematics" (1994 p.6). Students from different backgrounds develop a sense of dignity and self respect (Zaslavsky 1991) and also a feeling of sharing a common humanity. Adopting a culturally rooted mathematics curriculum will also introduce students to the various interactions between mathematics and other areas like music, arts, games, language etc. (ibid).

4.1.4 Ethnomathematics and Challenges of Globalisation

"Ethnomathematics is a contemporary global pedagogical trend in education" (Orey and Rosa 2007 p.12). The major pedagogical challenge for many societies today, is to arrive at a acceptable balance between modern, traditional and globalized aspects and demands of culture (ibid). To arrive as a desirable balance in this is one of the major challenges of ethnomathematics in a globalised society. This section reflects on some similar issues.

In our technology driven society, it is often lamented that the younger generation- who are the digital natives, (Sarukkai 2011) often lack ability to carry out mathematical operations mentally. The use of gadgets would mean that one does not have to think about the problem to seek a solution. Even in consumer stores see people calculate payments and balance on mobile phone calculators. In such a scenario what can ethnomathematics do to revive and revitalize the mathematics in everyday life?

The field of ethnomathematics is replete with studies that explore and expound the mathematics in everyday life of the people. Lave's study of the mathematical manipulations of home managers is just an example (1996). But how does ethnomathematics explain the loss of this everyday mathematical ability of the people and how does one comprehend -in this light - D'Ambrosio' advocacy for the use of calculators and others such gadgets in the classroom falls in stark contrast with his idea of spontaneous matheracy.

Confusions still abound, there are also attempts the way around, which claims a more relevant role of ethnomathematics in a globalized society. John A Fossa (2006) argues that ethnomathematics and co-operativism can be combined to foster sustainable economic development. He proves the point through his field experience of working with a marginalized community in North Eastern Brazil who were 'long dominant by paternalistic politics' (ibid). He argues for setting up co-operatives in such settings which is based on mathematic, logic and ethics. These three principles for him refer to the "proto-mathematical activities that have evolved in the community, the habitual patterns of reasoning and the basic ethical values and general outlook on life in the community" (p.35). By combining these three aspects of community life with the appropriate concepts and techniques from academic business mathematics, logic and practical ethics, Fossa aims to set in a dialogue between the two knowledge systems which will result in a validation of the community's knowledge as well as open up new vistas of intellectual growth. This process applied to home economics and local commercial dealings of the community like marketing of local products is suggested to foster sustainable economic development of the community.

Research has demonstrated that ethnomathematics can be combined with latest technology to give students innovative experiences of learning that opens their faculties to diverse ways of knowing and thinking (Sathya et.al. 2009). Ethnomathematical ideas and practices have also led to great advancement in computer sciences contributing to the picture language and to what is called Lindenmayer languages (Ascher 2002).

Garii (2008) puts forward a different perspective on ethnomathematics. She argues that 'technomath is ethnomath' and the dichotomy between Western mathematics and ethnomathematics overlooks this equation. For her mathematics theory and practice in a technological society is more embedded, and domain specific and thus ethnomathematical. In a technocratic world, the everyday reality of the learner is highly related to technology. Ethnomathematics can harness these technologies both as an aid for pedagogical program and also as a potential source of ethnomathematics (as a body of knowledge). She implores the teachers to use mathematical ideas implicit in film, music, computerized automation etc. to relate and explore the real world applications of mathematics.

Ethnomathematics' argument for the incorporation of aspects of child's (home) cultural background into school culture has to be understood in the wake of increasing cosmopolitanism. An immigrant child in a metropolitan anywhere in the world inhabits several different worlds simultaneously. At home she may be following her 'home' culture, her neighbourhood and peers may offer a different mix of cultural life, her school tries to bring in all the ingredients into a crucible and then there is a virtual world that presents itself as an overwhelming influence. Thus globalisation also challenges the selection of appropriate pedagogical tools and this ambiguity becomes more complex because ethnomathematics literature does not suggest the process or methods to define the 'appropriateness' of examples.

4.2 Ethnomathematics Curriculum Development

The strategies and modes of incorporating the ethnomathematical perspective in the mathematics curriculum have been debated intensely. It would be worthwhile to analyze some of these perspectives here for that will help to understand further the nature of interaction between ethnomathematics and conventional academic mathematics. Though most of the literature on ethnomathematics argues for an integration of ethnomathematics into academic mathematics, the proposed mode and nature of this integration differs. The distinction between ethnomathematics as a content to be incorporated into the curriculum and ethnomathematics as an approach that informs the curriculum is not a well maintained one.

Gelsa Knijik's (1993) 'ethnomathematical approach' seems to be reflective of this ambiguity. Her ethnomathematical approach refers to "research into the conceptions, traditions, and mathematical practices of a specific subordinated social group and pedagogical work involved in making the group members realize that:

1. they do have knowledge;
2. they can codify and interpret their knowledge;
3. they are capable of acquiring academic knowledge;
4. they are capable of establishing comparisons between these two different types of knowledge in order to choose the more suitable one when they have real problems to solve" (p.24).

Though the literature recognizes that there is a difference between ethnomathematics as an approach that informs the curriculum and ethnomathematics as a content that has to be incorporated into the curriculum (Adam et.al. 2003) at a more practical level this distinction seems to blur. Most of the studies on the educational aspects of ethnomathematics seek to investigate cultural traditions for mathematical ideas that can serve as examples in mathematics education. Such studies see ethnomathematics as a necessary link between 'm' and 'M'. However there are works that argue for a restructuring of the curriculum from an ethnomathematical perspective. For Orey and Rosa (1994), ethnomathematics is a "philosophical, contextual, affective, and attitudinal approach to the curriculum" (p.12).

"Ethnomathematics program deals with both the content and the process of curriculum, classroom management, teacher expectations, professional development, and relationships among teachers, administrators, students and the community" (Orey and Rosa 1994 p.12). Zaslavsky maintains that the aims of an ethnomathematics curriculum cannot be realized in a traditional mathematics curriculum because it is so rigid to allow room for any new perspective. She calls for a "complete turn- around from the way mathematics is now taught in many classrooms" (1991). However she does not propose a replacement of the present curriculum with ethnomathematics. Her argument is for a complete overhaul of the mathematics curriculum in a way that ethnomathematical elements are synthesized into it. Simply adding and stirring a couple of examples from different societies does not make any difference (ibid, Bishop 1988). Zaslavsky suggests a change in modes of learning as well as in methods of assessment. Instead of 'practicing' hundreds of problems devoid of meaning and reflection, ethnomathematically informed curriculum will be based on projects that deal with real life problems. The practice of assessment through multiple choice questions will give way to ongoing assessment of projects, evaluation of portfolios etc. the practice of streaming students on the basis of ability level determined by tests will also be abandoned (ibid).

Bishop (1988, 1994) also argues for a restructuring of mathematics curriculum. His contention is based on the broader definition of mathematics proposed by him. Bishop (1988) conceives of mathematics as a cultural product which develops through various activities in everyday life of the people. He lists six fundamental activities which form the basis of mathematics as a cultural knowledge - Counting, Locating, Measuring, Designing, Playing, and Explaining. He argues that these six cultural activities are the basis on which the edifice of western mathematics has been erected and thus forms a convenient basis for organising a mathematics curriculum. A mathematical curriculum based of these activities will present mathematics as a cultural activity and aims at mathematical enculturation by inviting the learner to reflect upon one's own cultural background.

Pinxten's approach to the pedagogical programme of ethnomathematics argues along slightly different lines. Though Pinxten follows Bishop's understanding of mathematics and its relation to ethnomathematics, Pinxten's education program does not explicitly call for a restructuring of the curriculum. According to Pinxten, the dominant mathematics curriculum embodies Western world view and hence does not relate to the life world of students in other cultural situations. Pinxten proposes that use of mathematical concepts and relations from child's cultural background, "to train these (other) native insights of the subjects in order to reach a level of understanding and sophistication in them which is already largely available (subconsciously) in the pre-school knowledge of the western child entering the curriculum" (p.25). Thus Pinxten convinces 'm' as a necessary stage in the development of the 'M'.

The 'm' leads to 'M' perspective can be discerned in the works of Orey and Rosa (1999) Eglash (1997) and also in D'Ambrosio (1993). Following D'Ambrosio (1993) and Eglash (1997) Orey and Rosa (ibid) proposes mathematical modelling as a strategy for the incorporation of ethnomathematics into mathematics curriculum. For them "mathematical modelling is a tool, which provides a *translation* from indigenous knowledge systems to academic mathematics" (p.11 emphasis added). Ethnomathematics puts forward mathematical modelling as a strategy for the incorporation of ethnomathematics into mathematics curriculum (D'Ambrosio 1983, Eglash 1997, Orey and Rosa 1999). "According to D'Ambrosio (ibid) mathematical modelling is a process of translation and elaboration of problems and questions growing from any real situation (system), which an image or sense of an idealized version of the system" (p.13, Orey and Rosa 2007). With the suggestion for the use of mathematical modelling as a major pedagogical tool, ethnomathematics envisages a learning process which is an activity, an active process of interaction between the learner, the teacher and the knowledge at hand. (Orey and Rosa 1994). It is argued that this reflection on the real life situations and the attempts at modelling them to mathematical problems will serve to develop a critical awareness as well as help them to engage in discussion about the development of mathematics and its role in society. Students develop the skills to collect data, analyse them and create hypothesis

(Orey and Rosa 2007). These skill can be used to reflect on issues of vital importance like health, environment, race, gender, socioeconomic class (ibid) and education itself. Ethnomathematics also adds to student's capacity building for critical thinking by encouraging group work, where students learn to respect and debate myriad opinions and alternate visions. "By facilitating student interactions in a globalized society, students share global and interactive visions necessary to develop successful mathematical content" (ibid p.13). It is also argued that the use of mathematical modelling as a methodological tool will help to ensure that ethnomathematics do not essentialize the past (ibid).

Ethnomathematics calls for a more complex reflection on reality hence encourages interactions between mathematics and other disciplines like biology, chemistry, physics, geography, history and language. (Zaslavsky 1993). However, the predispositions of the students, their capacity to learn in groups, the modalities of group projects all have to be thoroughly explored and that knowledge has to be integrated into the curriculum for ethnomathematics to realise its professed aim. The selection of a problem or activity to be incorporated into the curriculum proves the greatest challenge to an ethnomathematical curriculum. Orey and Rosa (2007) maintain that the selection of the ethnomathematical content should be based on the interest of the students, in order to sustain motivation and creativity in them (p.13), however, they note that such work "requires considerable background work, complete understanding, and pedagogical sophistication". (p.15) and also entails a risk of the claims of ethnomathematics perspective. Rowland and Carson (2002) point out that in a technological society, everyday mathematics would be related to technocratic culture and that there is a "...danger that schools could become labour training institutions to replace industrial/ commercial apprenticeships. In such a regime, the mathematics would not be for its own intrinsic worth but for interests of the employer" (p.85).

Another important challenge for incorporating ethnomathematics into the curriculum, the major challenge is to retain the context. The important point is to help the learner to navigate the transition from concrete to abstract. How is this transition effected in an ethnomathematical curriculum? At what level? What will the nature that transition? Thomas (1996) argues that ethnomathematics, while attempting to introduce context into mathematics education misses out the subject. He fears that "the baby may be going out with bathwater in some places" (p.110). He argues that ethnomathematics can be used as a starting point for motivating students, however a distinction should be made between proto-mathematics (or ethnomathematics) and real mathematics. For him the mathematics implicit in cultural activities or the 'mathematical ideas' in different cultural contexts are proto-mathematics and he reserves the term real mathematics to refer to the mathematics "which is no local society's ethnomathematics, only the global society's" (p.13). He says that to understand and advocate anything mathematical as 'mathematics' is similar to arguing that anything physical is physics. Thomas (1996) argues that to teach mathematics through proto-mathematics would deny the student opportunity to understand the way the mathematical-technological world of today works.

Though ethnomathematics literature argues for bringing in context into the classroom, the dynamics of power underlying this is not discussed much. They assume it as unproblematic and do not discuss the potential of such a move to create a more unequal and prejudiced situation (Setati)[50]. Ethnomathematics can potentially lead to the idealization of non-western cultures and thus reinforce the inequalities by perpetuating the status quo. There is also a "danger of ethnomathematics being a folkloristic introduction to academic mathematics" (p.14) (Orey and Rosa). Knijnik (1993) makes a point in this direction. She argues that the ethnomathematical approach shall not mean glorifying the popular knowledge. According to her mere glorification and perpetuation of indigenous knowledge will only reinforce the modes of domination. She disregards such an approach, because it does not have the potential to bring about social change. In her words, "when a specific

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[50]Setati,M. *In Response to Powell:Is Ethnomathematics = Matehmatics= Antiracism?* http://www.mes3.learning.aau.dk/Plenaries/Setati.pdf accessed 20/02/2011

subordinate group becomes conscious of the economics, social and political disadvantages which its scarce knowledge brings about, and tries to learn erudite knowledge, this type of consciousness may contribute to the process of social change"(p.25)

Orey and Rosa (2007) maintain that the features of ethnomathematics as a pedagogical movement will save ethnomathematics from succumbing to the idealization/ essentialization theories, and will ensure a positive outcome. These features according to them are

- "ethnomathematics looks forward, not backwards; that is ethnomathematics as an expression of contemporary thought.
- is not just a recording of historical ideas and practices
- assumes a sophisticated knowledge system because it is not just mathematical skills and drills". (p.13)

From a totally different perspective ethnomathematics is critiqued for blurring the distinction between indigenous ways of knowing with each other as well as with formal academic mathematics. It is argued that this will lead to a loss of uniqueness of the cultural traditions and instead of preserving them it may lead to their merging with the mainstream (Rowlands and Carson 2002). However, Adam, Alangui and Barton (2003) dismiss this critique and insist that ethnomathematics recognizes the uniqueness of each culture by emphasising its own ways of thinking and knowing. But it is also important to note that indigenous cultures are not static bodies of knowledge that do not change or respond in accordance with the changing needs of the community.

Ethnomathematical literature implores the cooperation of teacher, students, parents and the community in the formation of curriculum and in devising the pedagogy. However, bringing together each of these stake holders presents enormous challenges and their role has to be understood as complex and rooted in the socio-cultural ethos of the present education system. The investigation and research activities that will inform educational programs of ethnomathematics have been given prime importance. Because any curriculum restructuring has to be based on sound understanding of the subject as well as learner's background. It has to be backed by an understanding of angle of interaction between the teacher and the learner.

Ethnomathematics envisages a more active role for the teachers. "Teachers are characterized as facilitators, advisers, and mediators of the mathematics learning process" (Orey and Rosa 2007). Teachers in this system have "to be both flexible and knowledgeable in content because they are the ones who select cases that are related to student culture background and their environment" (ibid p.13). Teachers will make lesson plans in consultation with other teachers, parents and community. Special consideration will be given to students from underrepresented groups of students like girls, people of color etc.

The realization of all these changes would mean perspectival change in teacher training also. The identity and role of the teacher is located in t traditional school mathematics education and hence, it is difficult to reach the required level of politicisation and sophistication among the teachers. Orey and Rosa (2007) note that many teachers are reluctant to give away a authoritarian attitude for a more open one necessary for group interaction and learning among the students. Investigating and incorporating examples from the students cultural background implies that teachers learn from the students in a process of reciprocation. However, many teachers are not ready to enter this interactive learning mode.

The basic political motive behind an ethnomathematical curriculum is to emphasise the equality of alternate world views and thus to induce a sense of self respect and dignity in the students especially from under privileged and underrepresented backgrounds. This requires a greater level of politicisation among the teachers, because they are the most important point of delivery in an ethnomathematics informed mathematics education. Orey and Rosa (2007) note that "many mathematics educators are not always prepared to employ practices that will enable underserved and underrepresented groups to learn, understand, and comprehend mathematics" (p.14). This remains one of the major challenges for the implementation and success of ethnomathematics program and research has to focus on to activities through which this politicization of teachers can be achieved.

The politicisation of teachers and their induction into the paradigm of ethnomathematics is also important because, ethnomathematical activity requires more than simply including examples from the student's cultural background. It demands a contextualization of teaching, which requires creative pedagogical skills. Orey and Rosa (2007) give an instance of a complex situation that demands additional pedagogical skills from the teachers. They state, "it is convenient to state that teachers may interpret an ethnomathematical approach by starting with the student's outside socio-cultural economic realities, but the students may refuse to study their own realities because they consider them to be oppressive……. In this case, one possibility is to start with the students existing mathematical conceptions, even if they are traditional because this is another way to develop the mathematical content followed by a critical examination of these conceptions" (p.15).

Another important limitation faced by the teachers is the lack of time and resources to pursue the necessary investigation and plan the lessons. The present education system with fixed curriculum and pre-established lesson plans hardly gives any scope for creativity of the teacher (ibid). Moreover, pedagogical aids like textbooks or workbooks related to ethnomathematics are not easily available to teachers. The mode of assessment of an ethnomathematical learning process has also not been devised properly or they are not yet readily available to all. Only a few university courses in ethnomathematics are available for teacher trainees and this leaves them unprepared for the novel and complex task ahead (ibid).

Though most of the literature on the pedagogical program of ethnomathematics recognizes and emphasises the importance of teacher training for the success of ethnomathematics program they hardly discuss the ways to achieve a desired change. It is my contention that the ethnomathematics program has to pay equal attention to research into the incorporation of the ethnomathematics perspective in teacher education programs.

In a techno-centric world in which credentials matter more than learning satisfaction or development of critical thinking, it is not easy to convince the parents about the usefulness of an ethnomathematical curriculum. The utility approach to education is being reinforced by the day to day developments in the job market. An attempt to introduce a culturally interactive pedagogy as part of the DPEP (District Primary Education Program) in Kerala, India was received with great suspicion and criticism and many parents shifted their children to other schools which followed other syllabi based on the traditional pedagogic formula (Kumar 2003) and this in turn results in reinforcing the hierarchies in the society.

4.3 Ethnomathematics and Other Pedagogical Programs

When ethnomathematics is considered as a field of study with a particular perspective, it is difficult to distinguish it from other cultural perspectives on mathematics like multicultural mathematics and critical mathematics. However when seen as a body of knowledge, as the mathematics of this or that particular group then ethnomathematics can be seen as informing and aiding multicultural mathematics education and critical mathematics education, because the assertions and strategies proposed by these perspectives are more or less similar.

Rowland and Carson (2002) draw our attention to the overlap between ethnomathematics and other pedagogic philosophies that link epistemology with notions of emancipation and oppression. They point out that ethnomathematics' insistence on the 'doing of mathematics', its critique of academic mathematics as a formal, abstract system and its proposal for a "bottom up" cultural approach to mathematics is shared by radical constructivists, social constructivists and socioculturists. "For some radical constructivists, the doing of mathematics is exemplified in open-ended investigations (eg. Jaworski, 1994). For some social constructivists, the doing of mathematics is sometimes related to the needs, aspirations and perspectives of the class (eg. Ernest, 1991). For some socioculturists such as Jean Lave the doing of mathematics is related to the community of practice. For some ethnomathematicians, the doing of mathematics is the practice of mathematics among identifiable cultural groups (D'Ambrosio, 1997)" (p.84).

Ethnomathematicians hold that ethnomathematics is distinct from multi-cultural mathematics practices, which according to them has an 'exotic as well as a static vision on culture' (Francois and Kerkhove 2010 p.142). They argue that ethnomathematics differs from multicultural mathematics on various counts. Francois and Kerkhove (2010) capture these differences in ethnomathematical perspective in four principles.

1) "Mathematical designs are by no means autonomous, but are linked to other cultural expressions such as cosmology, spirituality, medicine....
2) The complexities of mathematical designs refute their alleged primitiveness.
3) Not only are the designs interpreted from a western perspective, for example looking for symmetries, but they are also analyzed with an eye on discovering underlying models that reappear in other designs.
4) They herald a dynamical view of culture" (p.142).

Francois and Kerkhove (2010) make a distinction between ethnomathematics and critical mathematics education. They argue that ethnomathematics has a third world origin, as a movement against the importing of western curriculum into these nations, which did not correspond to the learners background in any way. Critical mathematics education on the other hand, developed as a critical perspective on education which challenged the various types of discrimination that entails mathematics education. This critical mathematics perspective "...originated from within western high-tech societies criticizing the idea of linear progress and defining a number of suppression types, for example those based on class and gender" (p.140).

Conclusion

The major objective of ethnomathematics as discerned from the above discussion can be summed up as: "The inclusion of moral consequences to mathematical-scientific thinking, mathematical ideas and experiences from different cultures around the world, the acknowledgement of contributions that individuals from diverse cultural groups make to mathematical understanding, the recognition and identification of diverse practices of a mathematical nature in varied cultural procedural contexts, and the link between academic mathematics and student experiences could become a central aspect to a complete study of mathematics" (Orey and Rosa 2007 p.11). Contentions for incorporating ethnomathematics into mathematics education can be understood from two interrelated vantage points. One argues from a multicultural education perspective and the other provides a more critical ground from the perspective of the third world. However ethnomathematics lacks a reflexive approach that may illuminate the ambiguity in the project.

The confusion and contradiction in the methodology for ethnomathematical pedagogy reflects in ethnomathematical literature. "Much of the published ethnomathematics activities represent a shallow, superficial understanding of the field with a sense of 'multicultural experiences', based only upon 'exposure to diversity', and an inability to look at the deeper mathematics present" (Orey and Rosa 2007, p.14). There is not much evidence to suggest the effectiveness of the ethnomathematical program. Eglash (1997) observes that the lack of attention to theoretical precepts of ethnomathematics results from its direct applicability to education and development and this has in turn hindered any movement towards reflexive anthropology in ethnomathematics.

Notwithstanding these ambiguities ethnomathematics and the lack of evidence, ethnomathematics has marked its presence as a pedagogical movement with emancipatory potentials. "Ethnomathematics has brought cultural sensitivity into mathematics education research" (Rowlands and Carson 2002 p.93). Orey and Rosa (2007) argue that "an eventual inclusion of ethnomathematics in the school curriculum could happen simply because current trends in many urban schools (growing migration, immigration and the increasing complex, urban diversity of our populations) will demand it" (p.15).

Ethnomathematics as a pedagogic program is beset with ambiguities and hope. The success or failure of the program is yet to be witnessed. However, within the field of mathematics education ethnomathematics has emerged as a new movement seeking philosophical and pedagogical change.

Conclusion

Ethnomathematics was not a very natural choice for a topic of research. Mathematics as a school subject was not my favorite. Not because it appeared as untamable but because of the comments insinuating that as a girl I don't have a disposition for mathematics. I was repeatedly reminded that my success in the subject was only an outcome of hard work, which in mathematics meant practicing the problems without understanding them.

Ethnomathematics was like a new vision to me. Like Freire I felt that "inside me there is a mathematician that did not have the opportunity of awakening, and that I will die without having awoken this mathematician, who might have been a good one" (Freire, et.al. 1997 p.8). I realised that mathematics education as I confronted it was far less interested in awakening the mathematician in me. Thus ethnomathematics as an idea seemed very instructive personally; my socio- historical location in a third world nation formed the background. However, in the course of my research, whenever I answered the regular questions of 'what are you working on', I was countered with comments and questions which in fact helped me to perceive beyond the initial fascination with the topic.

"Ethnomathematics? Is it something like arithmetic or basic mathematics? For anyone who has some introduction to the field, these questions may see naïve. However, they do raise certain theoretical confusions underlying the field of ethnomathematics - is ethnomathematics a part of 'mathematics' like a subfield or is it an alternative conception of mathematics?

Some wondered if it is something akin to Vedic mathematics-and that led me to the issue of unwarranted appropriation and celebration of knowledge-which ethnomathematical perspective may end up doing.

Another question which haunted me everywhere, hinted on one of the most contentious methodological issues in ethnomathematics. My friends insisted that seeing is a subjective act, and 'ethno-mathematics' is in fact reinforcing the structures of certain knowledge, which accompany any such gaze. Issues of relativism and reflexivity were raised.

These questions are reflected upon throughout the dissertation. In the first chapter, I tried to understand the intellectual and political background of ethnomathematics. This was important to locate the field as well as my own intellectual trajectory which led me to the research problem that is ethnomathematics. Issues that ethnomathematics raises are deeply rooted in this background. Against this background the evolution of the field was traced from an idea, to concept and then into a perspective which was consolidated into a field. The process of establishing a disciplinary identity and legitimacy for the field is understood though epistemological and institutional negotiations which shape the field. A critical appraisal of the implications of the field took the discussion beyond description to a reflexive understanding of the field.

The dynamics of development of the field of ethnomathematics provides a reference to understand the politics and theory of knowledge production. Engaged in the polemics of multicultural theory and post colonial theory ethnomathematics negotiates a rapprochement between global and the local. In this attempt to encompass two distinct, but interrelated epistemological positions, the field finds itself embroiled in an intricate network defined by a complementary set of themes of power/knowledge, democracy/citizenship and multiculturalism/pluralism. Ethnomathematics appeals to each of sect of these set of issues.

At various points in the proceeding chapters it was pointed out that the power/knowledge dynamics which ethnomathematics assumes fails to understand the politics within a community. It does not provide a comprehensive explanation for the terms 'community' or 'cultural group' which forms the focal point of the investigation. For D'Ambrosio the term ethno includes 'all culturally identifiable groups with their jargon, codes symbol, myth, and even specific ways of reasoning and inferring" (1985 p.45).

This definition is as vague as the term 'ethno'. It lacks specificity and tends to overlook the diversity within a group. Defined in this was as pointed out by many scholars, academic mathematics is also an ethnomathematics-but that risks the politics of resistance, that ethnomathematics envisages.

The resistance that the field of ethnomathematics offers is also caught in this network of politics of knowledge that is manifested in the diversity of classificatory schemes. At what point is a system of knowledge called ethno-knowledge? When does it become an alternative to the mainstream? What are the prospects of it to replace the mainstream knowledge tradition? What would be the nature of the triangle formed by these three (ethno-alternative-mainstream) as vertices? Ethnomathematics literature eludes the reader on all these counts.

Though the idea of democracy and citizenship that ethnomathematics entails is empowering and vital for any third world nation, it seem to emanate from a utopian or ideal version of democracy and fails to ground the field in contemporary polity and society. An atmosphere of heightened cultural/religious activity marks the contemporary era along with the emergence of the neo- liberal nation state as the most hegemonic institution. The failure to locate the problematic of ethnomathematics thus will only result in romanticism.

This contradiction can be discerned in the attempt to negotiate the link between global and the local. Ethnomathematics fails to define its stance and location in the contemporary search for global history (Raina, 2007). Whether ethnomathematics aims at a history of global mathematics or at a global history of mathematics is still an unsettled issue. Moreover it needs to reflect on the potential of postcolonial theory and multicultural theory as a vantage point in the pursuit of its larger goal.

Finally, turning the reflexive lens on this dissertation as a descriptive study it draws on the literature from the field and attempts to understand ethnomathematics from what ethnomathematicians say about it. But a science studies perspective implores one to understand science in practice. This dissertation falls short of such an analysis, but can always serve as a prelude to an intensive ethnography of the field incorporating both qualitative and quantitative variables.

The dissertation ends with a more critical understanding of the field that replaces my own initial fascination.

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Appendix 1

Ethnomathematics in India

Socio-cultural and historical aspects of mathematics (Joseph 1991) and mathematics education (Panda 2004, 2006) in India have attracted attention of many scholars. Of late Indian folk practices were also scrutinised from mathematical point of view. A recent conference on *Mathematics and Folklore* in Calicut University, Kerala had several papers that discussed the mathematical elements in folk cultures of Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. Various aspects of the folk culture like mathematical symmetry in Malayalam riddles, mathematics in mehendi decoration, mathematics in Kalari, mathematics in Tamil orality etc were explored. However ethnomathematics as a perspective has not attained much visibility in Indian context.

Marcia Ascher's work on traditional Kolam designs of South India (2002) is a pioneering work on Indian ethnomathematics. Another major work that explored mathematics through the ethnomathematics perspective in Indian context was Nirmala Naresh's paper on the everyday mental computations of bus conductors in Chennai, presented at the Fourth International Conference on Ethnomathematics (ICME 4), 2010. Apart from these there have been some attempts to link ethnomathematics to technology based education. IIIT Hyderabad in association with some foreign universities and NGO's are working on a project that aims at developing low cost educational devices that make use of ethnomathematics to teach mathematics to students. They have made use of simple cultural forms like making bead necklace, tiling areas etc to teach fractions. A paper based on this was presented at the International Conference on computers in Education in (ICCE) 2009. A primary school teacher from Jharkhand, Shishir Bhadke's paper on the *Mathematical Ideas of Illiterate Market Vendors* was accepted for presentation at the Fourth International Conference on Ethnomathematics, Towson, USA, July 2010.

Apart from these fragmentary efforts there are a couple of university departments of research in educational studies that encourage work on ethnomathematics. The Zakir Hussain Centre for Educational Studies at JNU, New Delhi and the Homi Bhabha Centre for Science Education at TIFR in Mumbai has ongoing projects on ethnomathematics and mathematics education.

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