
ETHNOMATHEMATICAL CONFLUENCE/INTERSECTION OF NATIVE AND ACADEMIC WORLDVIEWSⁱ

CONFLUÊNCIA ETNOMATEMÁTICA
INTERSECÇÃO DE VISÕES DE MUNDO NATIVA E ACADÊMICA

CONFLUENCIA ETNOMATEMÁTICAS
INTERSECCIÓN DE LAS VISIONES DEL MUNDO NATIVO Y ACADÉMICO

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ABSTRACT

We adopt the concept of confluence as a metaphor to consider our ethnomathematical engagement for the past fourteen years. In this time, we have worked with students and teachers and have realized that the diversity of meanings brought to our collective mathematical commitment has had many influences. The principle of *two-eyed seeing* (MARSHALL, 2004), allows the authors a different framework through which to consider the importance of the Native worldview and a Western academic view. The confluence of the Native worldview and Western academic view is what guides our story. From the Native view we bring the richness of story and oral traditions. The Western side of our story brings forwarded a variety of academic backgrounds, e.g. mathematics education, linguistics, and anthropology. An overarching theme that we will bring forward is the affect. Affect for our students as well as us as researchers.

KEYWORDS: Ethnomathematics. Confluence. Native Worldview. Western Worldview. Mathematics Education.

RESUMO

Adotamos o conceito de confluência como uma metáfora para considerarmos o nosso compromisso etnomatemático nos últimos catorze anos. Durante esse tempo, trabalhamos com alunos e professores e percebemos que a diversidade de significados trouxe muitas influências para o nosso compromisso matemático coletivo. O princípio da *visão de dois olhos* (MARSHALL, 2004) permite aos autores um enquadramento diferente por meio do qual consideram a importância da visão de mundo nativa e da visão acadêmica ocidental. A confluência da visão de mundo nativa com a visão acadêmica ocidental é o que orienta a nossa história. Do ponto de vista nativo trazemos a riqueza da história e das tradições orais. O lado ocidental da nossa história traz o encaminhamento de uma variedade de conhecimentos acadêmicos, como, por exemplo, a educação matemática, a lingüística e a antropologia. Um tema abrangente que vamos apresentar é o afeto. Afeto para os nossos alunos, bem como para nós pesquisadores.

PALAVRAS-CHAVE: Etnomatemática. Confluência. Visão de Mundo Nativa. Visão de Mundo Ocidental. Educação Matemática.

RESUMEN

Adoptamos el concepto de confluencia como una metáfora para considerar nuestro compromiso etnomatemático durante los últimos catorce años. En este tiempo, hemos trabajado con estudiantes y profesores y nos percatamos que la diversidad de significados expresados en nuestro compromiso matemático colectivo tiene muchas influencias. El principio de la visión de los dos ojos (MARSHALL, 2004) permite a los

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autores un marco diferente a través del cual consideran la importancia de la visión del mundo nativo y de la visión académica occidental. La confluencia de la visión del mundo nativo y de la visión académica occidental es lo que guía nuestra historia. Desde el punto de vista nativo que traemos la riqueza de la historia y de las tradiciones orales. El lado occidental de nuestra historia trae consigo una variedad de conocimientos académicos, como, por ejemplo, la educación matemática, la lingüística y la antropología. Un tema general que vamos a presentar es el afecto. Afecto a nuestros estudiantes, así como a nosotros los investigadores.

PALABRAS CLAVE: Etnomatemáticas, Confluencia, Visión del Mundo Nativo, Visión del Mundo Occidental, Educación Matemática.

INTRODUCTION

For over fourteen years the authors have been collaborating on their development of ideas that may improve the mathematics education opportunities for Native American students. During this time, numerous others have contributed to the literature creating awareness of what has occurred, what could be occurring, and what can occur. Lately, we embrace the concept of *two-eyed seeing* as a way to consider the views of the two authors, one a Native American, the other Anglo. Our two-eyed seeing is done out of the conviction that mathematics education can be improved.

Shockey (2017) used the metaphor of confluence to describe ethnomathematics today: “The flowing together of water and the flowing together of ideas, it seems the dynamic nature of the water as it comes together with its swirling action is a nice way to reflect on the history of the ethnomathematics program” (p. 2). Ideas, as discussed by Shockey, come from other disciplines, for example Pike (1967), and his linguistic work on emic and etic, or the six dimensions of ethnomathematics (ROSA; OREY, 2016): cognitive; conceptual, educational, epistemological; historical; and political. Each of these disciplines provides ideas that can *swirl together* allowing new questions and insights to emerge. Where is the intersection of Native and Academic worldviews? We believe this confluence emerges in the principle of Two-Eyed Seeing as put forth by Marshall in 2004.

Two-Eyed Seeing is the Guiding Principle brought into the Integrative Science co-learning journey by Mi'kmaw Elder Albert Marshall in Fall 2004. *Etuaptmumk* is the Mi'kmaw word for Two-Eyed Seeing. We often explain *Etuaptmumk* – Two-Eyed Seeing by saying it refers to learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of Western knowledges and ways of knowing (...) and learning to use both these eyes together, for the benefit of all.

We believe that *Etuaptmumk* crosses boundaries into mathematics education, another confluence, and is a statement of altruism as Marshall reminds us, this should be *for the benefit of all*.

PAPER PRESENTATION

This position paper is organized as a dual autoethnography. Denshire (2013) citing Bochner (2006) highlights two categories within autoethnography, evocative and analytic. The evocative writing includes stories that are personal. With respect to the analytic, one of the broader phenomena we connect to is mathematics teacher preparation.

Ellis, Adams, and Bochner (2011) write that autoethnography is “grounded in personal experiences,” “accommodates subjectivity,” and “combines elements of ethnography and autobiography such that authors “write about past personal experiences.” According to Ellis et al. (2011) “in addition to telling about experiences, autoethnographers often are required by social science publishing conventions to analyze these experiences”. On strategy to do this is to “compare and contrast personal experience against existing research”. Our position using the metaphor of confluence through the paper is developed with respect to our personal experiences and existing literatures.

We first examine some historical writings that we feel address affect and what that meant in the past and could mean today. This is followed by some historical remarks on teacher preparation. Both of these sections are based on Western schooling. We then go into ethnomathematics as a lens to begin to unpack a Native view on mathematics education. All of these areas serve as input to our confluence of ideas.

Western Background

One concept we address is affect. According to McLeod (1992) “in the context of mathematics education, feelings and moods like anxiety, confidence, frustration, and satisfaction are all used to describe responses to mathematical tasks” (p. 576). We use the types of descriptors that McLeod stated as a way to view the historical account of statements by mathematics education leaders that are published in the National Council of Teachers of Mathematics Annual Yearbooks. For our purposes, we have chosen statements made by these leaders that from our perspective invoke emotion.

The emotion may be positive or negative. This focus is motivated by the reaction one of the authors has gotten for over twenty-years when he self identifies as a mathematics educator. Typically one of two responses are shared, ‘I loved math and was good at it’ or ‘I hate mathematics’. The emotion associated with these responses has been as strong as the shedding of tears by a friend describing her miserable experience with her mathematics teacher. To date there has never been any middle ground. In 1928 Schlauch describes an experience, which many learners in 2017 still endure:

Any normal child is blessed with natural curiosity – that heritage of the evolutionary struggle during which not to comprehend the environment and its dangers meant death. Children take joy in mastering knowledge which they can see has some relation to the phenomena of their lives. It is only the mass of abstract material in a dull curriculum, unpedagogically presented, that finally kills the desire to learn (p. 28).

Mathematics education should be embracing the natural curiosity brought to our classrooms, we should be providing learning opportunities that are joyful. It should not be inferred that learning should be simplified, we support challenging students with rich engaging curriculum by instructors with rich pedagogical approaches. During the development of this manuscript, one of the authors' sons was given an illustration of the unit circle and a table of the sine, cosine, and tangent values for a variety of angles. This sheet of information was provided the night before a major examination and the students were told to memorize the content for the next day's test. All these years later, this learner in 2017 experienced a 'dull curriculum' that was 'unpedagogically presented'.

Upton (1928) states there are five "laws of learning" (p. 138).

The first law of learning points out to inculcate any habit you must first create on the part of the pupil the *desire* to acquire that habit (p. 138).

The second law of learning states that to teach a habit you must supply a certain amount of *fundamental knowledge* concerning the habit to be formed. You do not want a child to form a habit blindly, in a purely imitative way. He should know what he is doing (p. 138).

The third law of learning states that in acquiring a new habit there must be sufficient *repetition* (p. 138).

The fourth law of learning reminds us that there must be provisions for the *practice* of the new idea or habit (p. 139).

The fifth law of learning indicates that some sort of *satisfaction* must result from acquiring the habit (p. 139).

Desire and *satisfaction* stand out as the affects that these five *laws* bring to the forefront. Handing a child a unit circle and telling him to *memorize it* does not create any satisfaction and possibly the only desire on the part of the learner is to make sure the content can be regurgitated in twenty-four hours on an examination sheet.

Considering the five laws of learning as advocated all those years ago by Upton (1928) begs the question of 'what should students have been learning?' According to Dower (1928):

Mastery of the fundamental facts and processes is not the ultimate end of arithmetical instruction. Life demands that boys and girls have not only a perfect mastery of the fundamentals of arithmetic but the ability to interpret, comprehend, and solve the quantitative situations that arise in everyday activities. This preparation may be brought about in two ways: 1. By giving specific preparation for the kinds of problems the pupils will meet in life [and] 2. By giving general preparation for all kinds of problems (p. 223).

In the United States, researchers have written extensively about the high-stakes testing, impact on teaching, teachers, and students. Maybe Dower (1928) was foreshadowing testing of this nature: “It is hopeless to expect children to be interested in problems which pertain wholly to activities foreign to their experiences” (p. 224). Testing for testing sake or that “one final examination” (REEVE, 1929, p. 132) can be elements of “activities foreign to their experiences”.

College entrance examinations grew out of a desire to standardize the mathematical product of the schools. The result of having each school determine what a pupil should know in order to enter any higher institutions was often chaotic. However, the results have sometimes been detrimental to the best interests of mathematics. Teachers should be encouraged to have a philosophy of their own and to teach the subject as it ought to be taught rather than try to prepare their pupils for *one final examination* (REEVE, 1929, p. 132).

The *everyday activities* of youth in 2017 are very different than what these leaders were writing about. There may be some truth to the cliché that we are preparing students to solve problems in their lifetimes, problems that have not been identified yet. When Reeve (1929) talks about there being differences in learners, we infer that part of the variation has to do with curiosity, joy, desire, interests, the affective concepts shared so far.

We are now giving serious consideration to the variation in the abilities and needs of individual pupils. This factor alone probably constitutes the greatest problem in the American secondary school to-day. Through tests of one kind or another we are now able to classify children into ability groups; and yet in many schools we go on with our teaching as though no difference exist. To continue such a practice is unwise (p. 174).

In 1929 differences in learners was a topic of discussion, a topic that continues today. What if an attribute in the differences then and now can be attributed to ‘dull curriculum’ that is ‘unpedagogically presented?’ There is irony that Langley (1930) recognized: “Our young people of to-day have such a variety of interests that it is quite natural for them to become impatient with a subject which appears to have little, if any, connection with ordinary existence” (p. 37).

The youth of to-day from kindergarten to college commencement is little interested in the infantile, senseless, or purely artificial problems with which our mathematics texts from arithmetic to calculus have been wont to be packed. Rather is he interested in what he sees actually going on around him everywhere, things and events that result in activity, in growth evident to the eye, in enjoyment, and whatever leads thereto. The youth of to-day is far more

sophisticated than was either his father or his grandfather at the same age, and the teacher of mathematics must play up to this fact (Roe, 1931, p. 100–101).

Today we hear similar remarks about mathematics.

Native Education

The works cited are not intended to be representative of Native education. Our intent is to highlight how Western education strategies sometimes are not generalizable and may be in conflict with local needs. Berger and Epp (2006) bring to our attention how some *common practices* do not fit all education scenarios: “but practices like praising individual achievement were reported by *Qallunaat* teachers and seem to be against Inuit culture, since historically Inuit did not often directly praise children for their accomplishments” (OKAKOK, 1989 as cited in BERGER; EPP, 2006, p. 10).

Berger and Epp (2006) wrote about the “practices against culture” that they identified in the writings of *Qallunaat* (this in Inuit term for non – Inuit people) (BERGER; EPP, 2006, p. 23) and Inuit writers. Berger and Epp explain that “by practices against culture, we mean teaching methods or ways of doing things that seem incongruent with historical or contemporary Inuit culture” (p. 10). In their research Berger and Epp (2006) citing the work of Stairs (1988), “formal education is not only alien to Inuit culture but, as initially transposed from the south, is in direct conflict with Indigenous modes of transmitting knowledge across generations” (p. 315).

According to the Nunavut Social Development Council (2000) as cited in Berger and Epp (2006), “formerly, Inuit learned by watching and imitating their elderS (...) Inuit values, beliefs and teaching methods were a way of living, interconnected with each other” (NSDC, p. 76-78 as cited in BERGER; EPP, 2006, p. 11). This Inuit worldview aligns with Cajete’s (1994) writing when he stated:

In Tribal education, knowledge gained from first-hand experience in the world is transmitted or explored through ritual, ceremony, art, and appropriate technology. Knowledge gained through these vehicles is then used in everyday living. Education, in this context, becomes education for life’s sake. Education is, at its essence, learning about life through participation and relationship in community, including not only people, but plants, animals, and the whole of Nature (p. 26).

These views are situated to acknowledge a conflict with classroom education. Abreu, Bishop, and Pompeu (1997) reminded us “out-of-school mathematics is essentially oral whereas school mathematics is predominantly written” (p. 253). Conflict, as noted above in the Inuit school, occurs particular to how power, values and knowledge are addressed.

The classroom situation is one where there is a symmetry of power between teacher and learners (BISHOP, 1991), resulting in certain values being developed rather than others, and certain forms of knowledge being accepted as more important than others. The learners from this relatively powerless position have their mathematical knowledge, attitudes, and beliefs shaped by the actions of their teachers (ABREU, BISHOP; POMPEU, 1997, p. 263).

We are not situating the blame for what occurs in mathematics classrooms on the teacher, “the teacher is only one person in a system which also may do little to recognize the learners’ cultural conflict” (ABREU, BISHOP; POMPEU, 1997, p. 253). The blame rests with the system.

The teacher must teach in relation to an agreed curriculum, and the text materials may not refer to anything other than the official school mathematics. Assessments and examinations will almost certainly be in strict agreement with standard curriculum. There can be little opportunity for the teacher to take into account out-of-school mathematical knowledge of pupils (ABREU, BISHOP; POMPEU, 1997, p. 263).

An outcome of this what the teacher “must teach” is, “The belief in the superiority of the school mathematics generates an asymmetry in the relationship between in-school and out-of-school mathematics” (ABREU, BISHOP; POMPEU, 1997, p. 252). The asymmetry is possibly exacerbated by language differences between teacher and student as explained by Barton and Frank (2001):

There have been the continuing linguistic and anthropological investigations into language and the “world views” they represent. Part of this has been renewed recognition of the work of Benjamin Whorf (LEE, 1996, WHORF, 1956) and the principle of linguistic relativity. This principle states that speakers of languages that are different structurally and grammatically are led to different ways of construing the world. Whorf, and his supervisor Sapir, used evidence from studies of Hopi and English to show how these languages resulted in different interpretations of events (p. 135-136).

Neatby (1953) in her discussion of electricity and how ludicrous she found some of the provincial descriptions of experiences students were to endure, wrote:

This fantastic mixture of the trivial and impractical defies comment. It is not intellectual or cultural; it is not even honest. It is an attempt to lure children into learning something they would not want to learn without some mild trickery. It is bound to fail, for children are not so easily taken in (p. 194).

While Neatby was writing about electricity, the point we make has to do with the asymmetry of power. Within this the structure described by Neatby, is the authority of the teacher. Gee (1996) as cited in Lipka, Sharp, Adams, and Sharp (2007), offers us a view for consideration when he introduces borderlands.

Gee's (1996) concept of borderlands describes the space where two cultures or linguistic styles meet by co-evolve into a practice that is not strictly either and becomes a new creation [confluence]. This is theoretically important. Classrooms have the potential for being these "third spaces": not necessarily those of the dominant culture, nor in a one-to-one correspondence with the local Indigenous or ethnic minority culture. These third spaces have the potential to become productive uncharted zones between school and local cultural knowledge and norms. From a critical pedagogical perspective, this third space has the potential to for changing historically situated authority structures (p. 97).

In Lipka's et al. (2007) work with Yup'ik communities introduces an important confluence that includes "joint activity" that could be considered by others working in Indigenous communities. "This notion of joint activity, we feel is part of the creation of a third space – a way to put together Yupiaq and Western pedagogy and the teaching of Yupiaq culture, language, and values, and in this case, mathematical knowledge" (p. 111). The joint activity is a geometric activity of patterns based on Yupiaq culture. According to Lipka et al., the classroom teacher was an active participant in making patterns with her students, she spoke to the children in Yupiaq while working on her own pattern. The teacher was not checking on the students' progress, students would seek assistance when it was needed. Students had the opportunity to look at one another's work as well as the work of their teacher.

Lipka et al. answer the question of why is joint activity important; "this culturally and linguistically-based activity of pattern making and module's emphasis on geometrical relationships creates an integral and authentic connection between the mathematics and socio-cultural norms embedded with Yupiaq culture and language and school-based mathematics" (p. 111). We feel the confluence of culture, linguistics, school and community norms are important considerations in Native education.

According to Cajete (1999), "Holistic learning and education has been an integral part of traditional Native American education and socialization until relatively recent times" (p. 53). Certainly Lipka et al. (2007) description above fits holistic education. Elements of holistic learning that are included by Cajete (1999) can be found in Lipka's et al. (2007) work: "experiential learning (learning by doing and seeing), storytelling (learning by listening and imagination), ritual/ceremony (learning through initiation), dreaming (learning through the unconscious and imagery), the tutor (learning through apprenticeship) and artistic creation (learning through creative synthesis)" (p. 55).

Cajete (1999) tells us that learning for Native Americans traditionally occurred in a "high-contexted social situation" (p. 53). By this Cajete means, "The lesson and the learning of the lesson was intimately interwoven with the situation and the environment of the learner" (p. 53). This was contrasted with the "low-context" of learning in Western schools. According to Cajete (1999) "low-context situations by their very nature are very specific and

transfer of information occurs in fixed arrays and structured patterns” (p. 53-54). What Lipka et al. (2007) report is *high context* learning.

Of the elements of learning brought forth by Cajete (1999), storytelling is noteworthy for its affect. “Storytelling was both an enjoyable and very effective means of teaching and learning in Native American traditional life” (p. 56). Storytelling was important element of the teaching by Mitchell as described by Shockey and Mitchell (2016). Mitchell was very adept at using stories to create enjoyment and laughter with students during their construction of a traditional Penobscot lodge.

The creative use of wit in the stories, or in the way a storyteller presented added to the enjoyment and “play” of the audience. Humor increased the psychological receptivity of the audience to what was being taught or conveyed. In many cases, wit in a story forced listeners to suspend their rational judgments and sense of reality and to consider the absurdity that might be a part of the story or its presentation, thereby developing a new perspective or understanding through creative synthesis (CAJETE, 1999, p. 56-57).

Shockey has observed the storytelling of Mitchell on numerous occasions. According to Lindquist and Smith (2016): “Laughter has always been a part of being Indian, and Native humor is culturally distinct and complex. Indigenous languages and storytelling are integral to the cultural uniqueness of Indian humor” (p. 28). The laughter of children when humor is interjected in teaching is contagious. Many times the authors are reminded of their Western educational experiences that did not include wit, did not include story, which for Mitchell is contrary to his learning within his community. For Shockey this has become an element of his pedagogy.

Language

Dr. Gregory Cajete, a Tiwa Indian from the Santa Clara Pueblo, is a highly regarded Science educator. He offers important insights that we feel are worthy of consideration in mathematics education. While we have cited him numerous times throughout this position paper, we feel it is important to introduce him at this juncture so as to give background to the reader. We feel this brief insight into Dr. Cajete is important for the reader when considering Cajete’s remarks on bicultural.

While some students are rediscovering their tribal identities, others are truly bilingual and bicultural. With these students, the bicultural approach to science is equally important, but for different reasons. Such students generally want to continue to learn and live within the context of both cultures. Instruction in bicultural science for these students can result in a positive attitude toward science and reaffirmation of their tribal identity. Another reason to use a bicultural approach to science instruction is that it provides a way to bridge differences in worldview concerning natural phenomena (CAJETE, 1999, p. 136).

While Marshall had not yet coined the phrase two-eyed seeing, we infer this is what Cajete is speaking to with respect to biculturalism and worldviews. We argue later that we can replace ‘science’ with ‘mathematics’ for bicultural students while considering a shift from acculturation to enculturation in mathematics education. With regard to bilingual Native students, we bring forward some linguistic work that we feel is an element of the confluence argument we are developing.

When we are open to multiple worldviews, we learn. Whorf (1950), in Carroll (1956), stated: “I find it gratuitous to assume that a Hopi who knows only the Hopi language and the cultural ideas of his own society has the same notions, often supposed to be intuitions of time and space that we have, and that are generally assumed to be universal” (p. 57). Whorf (1956) quoting Edward Sapir;

Human beings do live in the objective world alone, nor alone in the world of social activity as ordinarily understood, but are very much at the mercy of the particular language which has become the medium of expression for their society. It is quite an illusion to imagine that one adjusts to reality essentially without the use of language and that language is merely an incidental means of solving specific problems of communication or reflection. The fact of the matter is that the “real world” is to a large extent unconsciously built up on the language habits of the group (...) we see and hear and otherwise experience very largely as we do because the language habits of our community predispose certain choices of interpretation (WHORF, 1956, p. 134).

Whether we speak the languages of our learners, as mathematics educators we must be open to the impact of meaning. What we observe from a Western perspective, Pike (1967) referred to as the etic perspective, the outsider’s view, and what the students meaning, the etic, the insider view, regardless of tribe, we feel it is gratuitous to believe these will always have the same meaning. As mentioned earlier, the principle of relativity put forth by Whorf (1956) is worth re-stating here; “We are thus introduced to a new principle of relativity, which holds that all observers are not led by the same physical evidence to the same picture of the universe, unless their linguistic backgrounds are similar, or can in some way be calibrated” (p. 214).

As educators we must respect and listen to our students. If we do not understand their language, then we are responsible to seek assistance. “That American Indians speaking only their native tongues are never called upon to act as scientific observers is in no wise to the point. To exclude the evidence which their language offer as to what the human mind can do is liking expecting a botanist to study nothing but food plants and hot house roses and then tell us what the plant world is like” (p. 215). As we are building our confluence case, we are keenly aware that there are many more elements that we could bring to bear on this idea.

Learning

According to Cajete (1999a) “successful learning is tied to the degree of personal relevance the student perceives in the educational task” (p. 137). The student’s perceptions are related to their values. Cajete’s challenge for educators, in his case science educators, we replace science with mathematics, is to understand these values, “understanding and using the cultural constellations of values can provide the key to motivating Native Americans to learn science [mathematics]” (CAJETE, 1999a, p. 137).

According to Trumbull, Nelson-Barber, and Mitchell (2002), “School reforms over the past decade reflect a constructivist view of mathematics. In this view, individual students construct and understanding of mathematics concepts on the basis of their experiences within a community. The student’s personal experience base becomes a key to instruction and to understanding how student’s construct new information and experiences” (p. 2). Constructivism is a learning concept for all students, when Cajete use *personal relevance* we see this as synonymous with *their experiences* as stated by Trumbull et al. Learning concepts for Native students align with the general concept of constructivism, learning is a personal endeavor.

What then is required of teachers if we embrace the personal nature of teaching? According to Trumbull et al. (2002), “Thus, constructivist teaching places demands on teachers to form essential bridges between students’ lived experiences and the activities in their mathematics curriculum or to recast activities in contexts familiar to the students. Doing so requires teachers to have both a deep understanding of mathematics concepts and more understanding of students’ lives and culture than traditional teaching has demanded” (p. 2).

We feel ethnomathematics is a conduit for the bridge construction between students and their lived experiences. It is doubtful that Trumbull and colleagues were placing the burden for “understanding of students’ lives” solely on the shoulders of mathematics teachers. This approach has to be embraced by teacher education. Experiences for our preservice teachers that include ethnomathematical investigations using Bishop’s (1991) six activities, while not generalizable, begin to broaden teachers’ perspectives and could serve them well if they find themselves teaching in a community of which they are not a community member.

When Trumbull et al. (2002) tell us to rethink our view of mathematics instruction such that it is “an exercise in helping children connect real-world experiences that require mathematical thinking with classroom thinking” (p. 3), which we believe is an ethnomathematical connection. Revealing the benefit of connections, Trumbull et al. continue, “Through their real-world experiences children develop intuitive mathematical knowledge – ways of thinking about problems involving spatial relationships, number,

logical categories, and the like” (p. 3). Here the authors are leading up to the inclusion of a child’s ethnomathematics. “We are using the term ethnomathematics to mean the forms of mathematics that are embedded in cultural activities, in the workplace, the home, or in other community settings and are used by children or adults to carry out everyday tasks and solve problems” (NUNES 1992 as cited in TRUMBULL et al., 2002, p. 3).

There are important considerations for teacher preparation when we ask our teachers to attend to ‘forms of mathematics’ from the sources cited. A classroom teacher with a rich mathematics content background has what Pike (1967) would call the etic view, the outsider view, if the teacher is not a member of the community where she is teaching. According to Pike it is up to the “researcher” to discover the emic view, the insider view. We conjecture that ethnomathematical experiences as stated above, is an important step for consideration in teacher preparation. We do not suggest this as an add-on to teacher preparation, if we embrace the constructivist theory of learning for all children, then ethnomathematics in mathematics teacher preparation should be a cornerstone. The intuitive mathematical knowledge that children bring to the classroom likely has codes and jargons that may or may not be the language of academic mathematics, codes and jargons that D’Ambrosio (1985) recognized as important.

According to Trumbull et a. (2002) there are important pedagogical considerations for Native students that must be addressed. According to these authors, many classrooms are based on verbal exchanges that support trial and error, a concept that may not be embraced by Native students. Native students may come from an environment of observation. When the student has reached a personal comfort level with what was observed she might then attempt a demonstration of what she learned. Students from Indigenous communities are taught to respect Elders. If students’ stance is that the teacher is an *Elder* verbal interactions may not occur in the way desired by classroom teachers that are not members of the local culture. Out of politeness and respect, according to Trumbull et al. children may not interact with the teacher, the Elder.

Epistemology

We could expect that Dr. Shawn Wilson might argue that our metaphor of confluence is really a disguise for relationships. According to Wilson (2008), “beliefs include the way we view reality (ontology), how we think about or know this reality (epistemology), our ethics and morals (axiology), and how we go about gaining more knowledge about reality (methodology)” (p. 11). In his seminal work on Indigenous research methodologies, Wilson argues that relationships are most important. Wilson’s relationships are much more personal, “Indigenous epistemology is our culture, our worldviews, our times, our languages, our histories, our spiritualities and our place in the cosmos” (p. 74). In his

discussion of relationships, Wilson is spot on with respect to how analysis from a Western perspective is in conflict with an Indigenous view.

So Analysis from a western perspective breaks everything down to look at it. So you are breaking it down into its smallest pieces and then looking at those small pieces. And if we are saying that an Indigenous methodology includes all these relationships, if you are breaking things down into their smallest pieces, you are destroying all of the relationships around it. Indigenous style of analysis has to look at all those relations as a whole instead of breaking it down, cause it just won't work (WILSON, 2008, p. 119).

Cajete (1999a) cautioned us as to the inappropriateness of this breakdown of science. In mathematics education, we frequently encounter disbelief when our students are not able to reassemble the content's smallest pieces when problem solving. Considering the components identified by Wilson with respect to Indigenous epistemology, it begs the question of how can mathematics teacher education work with educators that will teach Native students? There is no one, Native epistemology; therefore the preparation of mathematics teachers cannot assume a one size fits all approach.

Ethnomathematics

We are purposeful in placing ethnomathematics prior to our conclusion. We provide a brief historical perspective on ethnomathematics for the purpose of identifying elements that have contributed to the scholarship. Rohre and Schubring (2011) brought to the world's attention that Fettweis had used the phrase ethnomathematics during the 1930's. Fettweis' 1927 dissertation was titled *The Numeracy of Primitive Peoples* and later "produced numerous publications evaluating ethnographic findings, in particular about numeracy and reckoning procedures" (ROHR; SCHUBRING, 2011, p. 36). This fits in the framework of Kuhn (1962) for the development of a scientific theory, according to Rohre and Schubring as an element of the pre-paradigmatic period that included Ewald Fettweis (1881-1967), Otto Friedrich Raum (1903-2002) and Georges-Henri Luquet (1876-1965) as the "pre-paradigmatic scientist of ethnomathematics" (p. 35).

According to Rohre and Schubring (2011), the research agenda of Fettweis was a personal development since his two advisors, Study (geometry of complex numbers) and Dyroff (philosopher), neither of which "is known to have promoted ethnology or ethnography" (p. 36). It is an open question how these academics influenced one another, to date we are not aware of a translation, or the availability of Fettweis' dissertation. In a:

(...) programmatic paper published in 1937, Fettweis fervently pleaded for a close collaboration between ethnology and the history of mathematics. He argued that in the cultures researched by ethnologists, one should be able to unravel the roots of mathematical development in the first civilizations of Antiquity. And he insisted that the history of science has to embrace the entirety of humanity, so that the

development of the so-called 'lower degree civilizations' (*niedere Kulturen*) should also contribute to the "tree of mathematical sciences" (FETTWEISS, 1937, p. 277-278 as cited in ROHRER; SCHUBRING, 2011, p. 37).

Here we cite, in our view a first confluence, the pre-paradigmatic phase of ethnomathematics.

Since D'Ambrosio's (1985) definition of ethnomathematics, many scholars have offered their definitions (ASCHER, 1986; BORBA, 1990; GERDES, 1993). While the field of mathematics education has served as a home for ethnomathematics, there are many influences on the scholarship, for example from the preface of *Funds of Knowledge* (GONZALEZ, MOLL; AMANTI, 2005), "Learning does not take place just 'between the ears' but is eminently a social process (...) people are competent, they have knowledge, and their life experiences have given them that knowledge (...) by focusing on understanding the particulars, the processes or practices of life (in Spanish *los quehaceres de la vida*), and how people lived experiences, we gained a deep appreciation of how people use resources of all kinds, prominently their funds of knowledge, to engage life" (p. ix).

According to Albanese, Adamuz-Poredano, and Bracho-Lopez (2016) "At the beginning of its history, Ethnomathematics had the purpose of recognizing ideas and practices of different cultural groups but then it evolved to embrace wider studies centered on the ways the cultural and social context affects the process of generating, organization and communication of knowledge." Albanese et al. (2016) propose "two views of Ethomathematics that respond to this evolution: 1) mathematics of cultural practices; 2) different ways of thinking". Our proposed confluence metaphor is proposed to support a different way to think about the mathematics education of Native students.

CONCLUSION

We feel the metaphor of confluence fits our needs to understand the many influences that can positively impact mathematics education for Native students. We would not argue with the critic that highlights the age of many of our citations. We would counter, the message has been delivered from many different groups, for many years, and maybe it is worth repeating again how important it is to be student centered. According to Cajete (1999a) "most science educators have determined that if non-Western explanations of natural phenomena do not fit the western scientific framework, the are not scientific" (p. 146). It could be argued that prior to D'Ambrosio's (1985) coining of ethnomathematics, this was a belief in mathematics. With the scholarship of ethnomathematics comes a more open view and acceptance for mathematics educators working with learners away mainstream society.

Cajete shared the conflict that exists in science between “two distinctly different worldviews: the mutualistic/holistic oriented worldview of Native American cultures and the rationalistic/dualism worldview of science that divides, analyzes, and objectifies” (p. 146). We ask readers to open the table of contents of a school textbook, which worldview is suggested? To an extent the presentation of confluence of ideas is not holistic. Our intent is to take the ‘big picture’ apart, not completely, to reveal that there are indeed a confluence of concepts, principles, and ideas. We know the following occurs, we do not agree:

Much of modern education involves to one extent or another imposing a preconceived psychological pattern of “right ways to do things” and “wrong ways to things.” In public schools, this pattern involves imposing a modern American societal will on all those who participate in American public education. However, imposing such a societal will upon what is taught and how it is learned, many students are denied use of their own innate repertoire of intelligences and cultural styles of learning. Learning by simply doing, experiencing, and making connections that coincide with the personal and cultural intelligences and learning styles students bring with them from home can be significantly diminished through such a homogenization of the education process (CAJETE, 1999a, p. 145).

We appreciate that part of our thesis is in support of culturally responsive teaching. According to Pewewardy and Hammer (2003), culturally responsive teaching is a response to the confluence of such scholarship areas of “anthropology, sociology, social history, psychology, and applied linguistics” (p. 2). From an academic viewpoint, it may be more specific to consider culturally responsive teaching as a confluence of scholarship.

Trumbull et al. (2002) tell us how mathematics instruction needs to improve, we need to move away from an “instructional sequence in mathematics [that] has required students to master skills and facts first and then learn to apply them” (p. 2). Why is this important, consider the importance of holistic approach forwarded by Wilson (2008) and Cajete (1999a). We agree with the ideal model offered up by Trumbull et al. (2002) “in our ideal vision of mathematics instruction the following components would be included: (1) ethnomathematical knowledge and intuitive mathematical knowledge (i.e., mathematics based on experiences), (2) symbolic representation and procedural knowledge, and (3) principled, or theoretical knowledge” (p. 4-5).

This progression of ethnomathematical knowledge through theoretical knowledge requires reconsideration by mathematics teacher preparation. We cannot expect that our learners will necessarily recognize the “mathematics” in their lived experiences. Davidson (2002) interviewed a number of Native students, learning that a number of them participated in cultural activities, of which Davidson recognized as mathematics but the students “did not regard the cultural activities as intrinsically mathematical” (p. 19). Davison was an early leader in ethnomathematics, this scholarship background allowed him to *see* the mathematics, this background could broaden the view of our mathematics teachers.

Davidson (2002) acknowledges, “the problem, then, is the development of culturally rich examples to be used with learners from a variety of backgrounds” (p. 19). The pioneering work of Lipka (2007) reveals that culturally rich examples can be developed in collaborations between communities and the academy. Inclusion of ethnomathematics in teacher preparation may allow teachers to see the mathematics through activities that engage Bishop’s (1991) six cultural activities. Ethnomathematics can be an focus in professional development sessions for our inservice mathematics teachers as well. New educators arriving in communities of which they are not a member can begin the important work of building pedagogical bridges if they have backgrounds described throughout this paper.

Everything noted thus far, our intent was not to be exhaustive identifying elements that comprise a confluence of ethnomathematical teacher preparation, begins to underscore the challenges that mathematics teacher preparation can choose to address. Mathematics education oftentimes approaches teacher preparation as a *one size fits all*. We agree with Davidson (2002) when he stated; “When mathematics instruction occurs in only one cultural context, whether dominant or not, students from other cultures are placed at a learning disadvantage” (p. 19). If ideas of culture are included, these ideas are add-ons to existing programs. We have found that the idea of preparing teachers of mathematics with insights to understand students’ lived experiences is foreign. Too often teacher preparation, similar to K-12 education in the United States, is judged by the exit scores candidates earn on standardized testing. Too often preservice teachers are being prepared for the exit test, not for the lived experiences of the students they will teach and learn from.

We feel the following quote can be inclusive of all our children “When the important cultural values of Indigenous students are not reflected in what they see of mathematics and science, the students may conclude that they must ignore some of their own values to participate in these domains. As a result, they may choose not to pursue these subjects at all” (TRUMBULL et al. 2002, p. 8). A lack of two-eyed seeing does a disservice to our learners. Ethnomathematics and two-eyed seeing begin to construct firmer footing for bridges between classrooms and our learners’ community, bridges that are necessarily two way between the academy and community. Certainly community members prepared to return to their local schools as educators have advantages, but we support teacher preparation that allows all of our children to be positively engaged and affected by their schooling experience.

The negative affect of mathematics experiences for Native students is not necessary. Davidson (2002) reminds us that:

Students are participants in two cultures – the culture of the home and the culture of the school. American Indian students see little connection between these two cultures; consequently, many potentially rich situations from the Native culture are lost to the school. This outcome is particularly true in mathematics, where Native American students feel alienated from the mathematics curriculum. I believe that these students would see more purpose in their school mathematics if it were more closely linked with appropriate aspects of their culture (p. 24).

For too many students their mathematics experience is one of acculturation. According to Pallascio, Allaire, Lafortune and Mongeau (2002) “Mathematical acculturation refers to the process by which a social group, and ultimately each of its members, actively construct mathematical knowledge on the basis of experience in a sociocultural environment that is not their own” (p. 58). Current mathematics education preparation continues a cycle of mathematical acculturation. Pallascio et al. (2002) share that in a tribal community, for important learning a particular tribal member would be sought, this is the individual that understands the needed learning the best, the individual that guides the learner through enculturation. This type of choice does not exist in schools.

Pallascio et al. (2002) proposed the following, “Is it possible to in the long term to convert this process of acculturation into a process of enculturation, which makes greater allowances for the student’s culture and can involve, for example a reformulation of the “didactic contract” (i.e. the pupils implied expectations of their teacher and vice versa) (Brousseau and Centano 1991) and on ethnomathematical interpretations of the knowledge that is required” (p. 59)? Our response in a word, yes. We realize there many challenges and certainly politics that would need negotiated for a movement from acculturation to enculturation. Pallascio et al. (2002), quoting the work of Pinxten (1994) who “asserted that learning is a cultural phenomenon and that the contents of the learning processes are culturally specific” (p. 60) which for us suggests multiple Indigenous epistemologies, a challenge. There is overlap in learning in Indigenous communities, is that enough to support the movement from acculturation to enculturation, maybe.

Citing the work of McIntosh (1983) and Leder (1995) to support a five phase enculturation process, Pallascio (2002) suggest the following:

Phase 1 – Mathematics Acculturation

All mathematical ideas are influenced by the culture of those who have constructed them. In the context of acculturation, the presentation of new notions is achieved by means of placing these notions in opposition to the cultural influences of the people who must assimilate them.

Phase 2 – Mathematics that includes cultural connotations

In the second phase of enculturation, the presentation of new notions is achieved by using traditional objects and terms having a cultural connotation.

Phase 3 – A cultural split

In this phase, members of a culture adopt two different perspectives on mathematics, since in a certain way the individuals straddle two cultures – their traditional culture and the element of other cultures that are developing in the midst of their own society. In this context, how do children view mathematics? It appears they have two frames of reference, one developed in connections with the school mathematics and the other related to the problems of everyday life.

Phase 4 – Cultural interactions

At this phase of enculturation, we are at the heart of the relationships among mathematics, knowledge that children need to learn, world views, and culture. The traditional categories encountered in school mathematics are culturally colored; alternative approaches might prove more appropriate. For example, categories based on such examples as counting, locating, measuring, drawing, playing, and proving (Bishop, 1988) are all examples of categories that mathematically acculturated societies could assimilate.

Phase 5 – Mathematical enculturation

This phase consists of developing alternative approaches to mathematical teaching that are capable of encompassing:

- aspects of the traditional culture (world views, particular knowledge, specific attitudes toward learning, etc.);
- aspects of popular culture (expressions, behavior, students' experiences, etc.)
- mathematics (contents, processes, teaching methods) related to the educational objectives of the community;
- the needs of students (social, economic, etc.);
- the integration of learning experiences in a way that is mindful of community needs (p. 60-61)

Maybe these five phases begin to provide answers as to how “classrooms need to integrate culture into curriculum to blur the boundaries between home and school. School’s need to become a part of, rather than apart from, the communities in which they serve” (CLEARY; PEACOCK, 1998, p. 157). Better community and school relationships we contend, would better serve students in all content areas.

Our central thesis of confluence, we feel, broadens the conversation of mathematics education, but more specifically the discussion on ethnomathematics. We promote the importance of relationships and the need for academics to improve their response. Ethnomathematics is a confluence of concepts and ideas, all of which are important in a two-eyed seeing agenda of mathematics education for Native students.

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