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SPECIAL FEATURE

BLENDING COMMUNITY SCIENCE IN THE CLASS ROOM – HAUSA PROVERBS AND EFFICACY OF ETHNOSCIENTIFIC METHODOLOGY

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INTRODUCTION

In this discussion, I look at science teaching from the perspectives of social and cultural theory, adopting a standpoint that considers science as cultural enactment and part of community resources of learning. This is crucial in the sense that a barrier is often created between science and cultural environment, giving the impression that science can only be taught or learnt in a specially designated environment and by specially designated learner. When science is transmitted like any other forms of cultural expression, a link is created between what is understood to be science, and what eventually turns out to be science. In this axis, therefore, I want to focus our attention on scientific concepts that exist within the cultural theory of orality of the Muslim Hausa of northern Nigeria, and provide science teachers with ready-resources for teaching scientific concepts more effectively.

Keywords: Culture, Environment, Hausa, Proverbs, Science

According to VMSC TASK FORCE (2013, p. 5). Science is a body of knowledge that goes beyond the boundaries of what constitutes scientific knowledge by including components that not only add value to that knowledge, but also distinguishes it. These compoments include knowledge of science itself, its methods, and its nature. VMSC Task Force 2013, p. 5) captures these interconnections in Fig. 1.

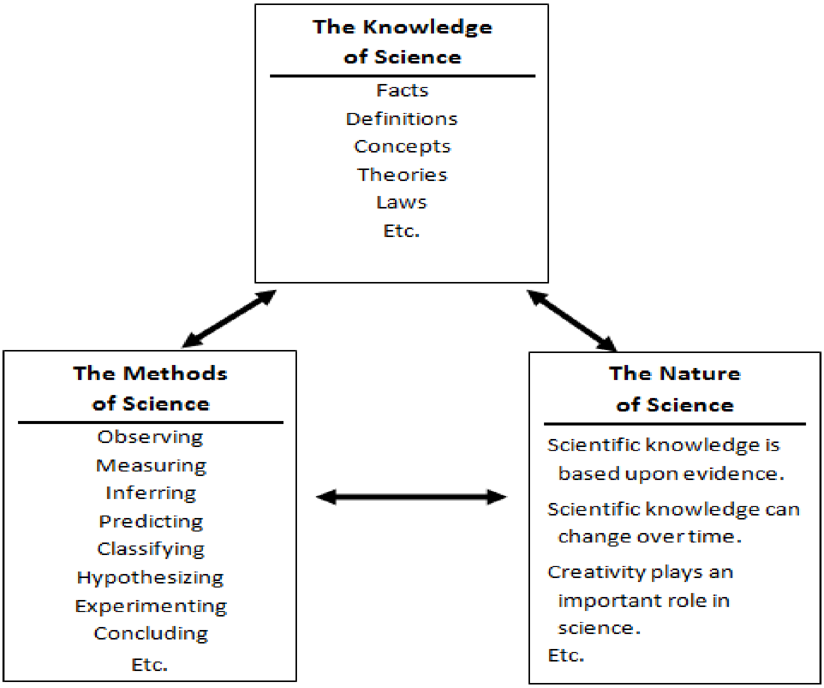

Fig. 1. Three components of scientific literacy (VMS Task Force, p. 6)

These components were explained by the Task Force as:

- ***Scientific knowledge***, the most familiar component of scientific literacy, includes all of the scientific facts, definitions, laws, theories, and concepts we commonly associate with science instruction.
- The ***methods of science*** refer to the varied procedures that scientists use to generate scientific knowledge. While these methods can be very complex, secondary science instruction typically focuses on the more basic inquiry skills, including observing, inferring, predicting, measuring, and experimenting.

Additionally, scientific inquiry refers to a specific instructional approach in which students answer research questions through data analysis.

- The ***nature of science*** is the most abstract and least familiar of the three components of scientific literacy. The nature ofscience addresses the characteristics of scientific knowledge itself and is perhaps easier described than defined. It depicts science as an important way to understand and explain what we experience in the natural world, and acknowledges the values and beliefs inherent to the development of scientific knowledge (Lederman, 1998). These three essential components of scientific literacy are highly interrelated and secondary science instruction should reflect the synergy that exists among scientific knowledge, methods of science, and the nature of science. Finally, a basic understanding of mathematics and the nature of mathematics is one additional, necessary component to develop scientific literacy among students (AAAS, 1990).

What is Scientific Inquiry and Why Teach It?

Inquiry is at the heart of the scientific enterprise, and as such, demands a prominent position in science teaching and learning. The American *National Science Education Standards (NSES)* refer to two important aspects of inquiry that are important to science instruction. "Scientific inquiry refers to the ways in which scientists study the natural world and propose explanations based on evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (NRC, 1996, p. 23).

Engaging students in scientific inquiry is an important component of science instruction that helps students develop scientific literacy and provides them with the opportunity to practice important science process skills in addition to critical thinking and problem solving skills. Further, research suggests that engaging students in scientific inquiry can lead to achievement gains in science content understanding and critical thinking and problem solving skills (Bransford, Brown, & Cocking, 2000).

The *NSES* describe both the essential understandings students should have about inquiry and the essential abilities necessary for students to do scientific inquiry (NRC, 1996). According to the *NSES,* students should understand that:

- scientists use many methods to conduct a wide variety of investigations;
- scientists rely on technology & mathematics; and
- scientific explanations must be logically consistent, abide by rules of evidence, be open to questions & modification, and be consistent with current scientific knowledge (NRC, 1996).

In order to engage in scientific inquiry, the *NSES* propose that students should:

- design and conduct scientific investigations;
- use technology and mathematics;
- formulate and offer explanations using logic and evidence; and
- communicate and defend a scientific argument (NRC, 1996).

Teaching Scientific Inquiry

Far too often, teachers equate inquiry instruction with hands-on activities. While inquiry instruction is student-centered in that students are actively engaged, not all hands-on activities promote inquiry. Conversely, not all inquiry activities must be hands-on. It is possible for students to engage in inquiry through analyzing existing data, without the need for hands-on data collection. Many teachers believe that in order for students to engage in inquiry-oriented activities they must design investigations and carry them out on their own. This perception is too narrow. Students cannot be expected to design and carry out valid investigations without substantial support and instruction. Therefore, teachers should scaffold inquiry instruction to enable students to develop their inquiry abilities and understandings to the point where they can confidently design and conduct their own investigations from start to finish (Peters, 2009). Further, instructional objectives should play a significant role in the design of an inquiry-based activity for a particular lesson. Luft, Bell, & Gess-Newsome (2008) provide content-specific examples of inquiry lessons that provide varied levels of support by teachers and are appropriately aligned with instructional objectives. In some lessons, it might be best for students to learn a science concept inductively through inquiry-based experiences. For other lessons, the focus may be on developing specific inquiry skills, such as measuring and using lab equipment to collect data.

Is it inquiry? The primary question to consider when determining whether an activity is inquiry-based is: Are students answering a scientific question through data analysis? Many worthwhile hands-on activities traditionally performed in science classrooms do not involve students in these essential components of inquiry. For example, constructing a model of the atom, organizing a leaf collection, or building a soda-bottle water rocket can all be excellent instructional activities. However, unless these activities involve research questions and the opportunity to analyze data, they do not qualify as inquiry activities.

Thus, when evaluating whether an activity involves students in scientific inquiry, the first question for teachers to ask is:

Does the activity include a research question?

Specifically, does the activity include a research questions that can be answered through a scientific investigation? Examples of appropriate research questions include:

- Does the moon rise and set at the same time every night?
- How does concentration influence the rate of a particular reaction?
- What effect does the intensity of light have on plant growth?

Each of these questions can be answered through analysis of observational or experimental data. Note that scientific questions may be posed by the teacher or students, depending on the specific goals of the lesson and abilities of the students.

The second critical question in evaluating whether an activity supports inquiry is: ***Do students engage in data analysis to answer the research question?*** Activities in which students are simply gathering information from secondary sources via Internet or library research are not inquiry activities. Students must analyze data themselves. Note, however, that students do not necessarily need to collect their own data in order to satisfy this condition.

Data can be presented by the teacher to students for analysis or obtained from other sources such as the Internet or a simulation. At the heart of this question is "Are students doing their own data analysis to draw conclusions and answer the research question?" It is essential to note that activities engaging students in pure observation may be inquiry-based if they meet the above criteria. It is not necessary for students to design and carry out *experiments* in order to do inquiry.

What is the Nature of Science?

Understanding and actively engaging in scientific inquiry is only part of the picture when it comes to developing scientific literacy. Equally important is an understanding of the nature of science, or "science as a way of knowing." The nature of science has been defined in a variety of ways, and these definitions are hotly debated among philosophers and sociologists of science (Lederman, 2007). Some science educators have defined the nature of science as "the values and assumptions inherent to the development of scientific knowledge" (Lederman, 1992). One assumption central to the scientific enterprise is that the universe is knowable. Many of the assumptions and values related to the scientific endeavor are too abstract and esoteric to be meaningful to secondary school students (Abd-El-Khalick, Bell, & Lederman, 1998). Therefore, the major science education organizations have delineated the nature of science concepts that should be addressed in secondary school classrooms (AAAS, 1993; NRC, 1996; NSTA, 2000). These documents paint a consistent picture of the nature of science that is most appropriate for developing scientific literacy among students and there is little debate over these key components of the nature of science appropriate for secondary instruction (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; Osborne, Collins, Ratcliffe, Millar & Duschl, 2003). Following is a brief description of seven key characteristics of the nature of science.

1. **Scientific knowledge is empirically based.** "Empirical" refers to knowledge claims based upon observations of the natural world. While some scientific ideas are theoretical and are derived from logic and reasoning, all scientific ideas must ultimately conform to observational or experimental data. Empirical evidence, in the form of quantitative and qualitative data, forms foundation for scientific knowledge.
2. **Scientific knowledge is both reliable and tentative.** Scientific knowledge should not be viewed

as absolute, but tentative and revisionary. For example, many scientific ideas have remained largely unchanged over long periods of time; however, scientific knowledge can change in light of new evidence and new ways of thinking. New scientific ideas are subject to skepticism, especially if they challenge well-established scientific ideas. Once generally accepted by the scientific community, scientific knowledge is durable. Therefore, it is reasonable to have confidence in scientific knowledge while still recognizing that new evidence may result in changes in the future. Related to the tentative nature of science is the idea that regardless of the amount of empirical evidence supporting a scientific idea (even a law), it is impossible to prove that the idea holds for every instance and under every condition. Einstein's modifications to the well-established Newtonian Laws are a classic case in point. Thus, "Truth" in the absolute sense, lies outside the scope of science (Popper, 1988). Scientific laws do not provide absolutely true generalizations, rather, they hold under very specific conditions (Cartwright, 1983, 1988). Scientific laws are our best attempts to describe patterns and principals observed in the natural world. As human constructs, these laws should not be viewed as infallible. Rather, they provide useful generalizations for describing and predicting behavior under specific circumstances.

3. **Scientific knowledge is the product of observation and inference.**

Scientific knowledge is developed from a combination of both observations and inferences.

Observations are made from information gathered with the five senses, often augmented with technology. Inferences are logical interpretations derived from a combination of observation and prior knowledge. Together, they form the basis of all scientific ideas. An example of the interplay of observation and inference is the manner in which we determine the distances to stars. Stars are so far away that only a relatively small fraction of star distances can be measured through direct observation and the application of geometry. For the rest of the stars and other distant celestial objects, a complex combination of observations and inferences must be employed (see Murphy & Bell, 2005 for a more complete description of how astronomers determine distances to stars).

4. **Scientific knowledge is the product of creative thinking**. Scientists do not solely rely on logic and rationality. In fact, creativity is a major source of inspiration and innovation in science. Scientists often use creative methods and procedures throughout investigations, bound only by the limitation that they must be able to justify their approaches to the satisfaction of their peers. Within the limits of peer review, creativity permeates the ways that scientists design their investigations, how they choose appropriate tools and models to gather data, and in how they analyze and interpret their results. Creativity is clearly evident in Darwin's

synthesis of the theory of natural selection from a wide variety of data and ideas, including observations from his voyage on the *H.M.S. Beagle*, his understanding of the geologic principles of Lyell, and even Malthus' theory of populations. Although known as a careful and methodical observer, Darwin's recognized genius stems from his creative work of synthesizing a powerful scientific explanation from a variety of sources and clues.

5. **Scientific laws and theories are different kinds of scientific knowledge.** A scientific law is a description of a generalized relationship or pattern, based on many observations. Scientific laws describe *what* happens in the natural world and are often (but not always) expressed in mathematical terms. Scientific laws are simply descriptive—they provide no explanation for why a phenomenon occurs. For example, under relatively normal conditions, close to room temperature and pressure, Boyle's law describes the relationship between the pressure and volume of a gas. Boyle's law states that at constant temperature, the pressure of a gas is inversely proportional to its volume. The law expresses a relationship that describes *what* happens under specific conditions, but offers no explanation for *why* it happens. Explanations for why this relationship exists require theory. Scientific theories are well-supported explanations for scientific phenomenon.

   Theories offer explanations for *why* a phenomenon occurs.

For example, the kinetic molecular theory explains the relationship expressed by Boyle's law in terms of the inherent motion of the molecular particles that make up gases. Scientific theories and laws are similar in that both require substantial evidence before they are generally accepted by scientists. Additionally, either can change with new evidence. However, since theories and laws constitute two different types of scientific knowledge, one cannot change into the other.

6. **Scientists use many methods to develop scientific knowledge.** There exists no single "scientific method" used by all scientists. Rather, scientists use a variety of approaches to develop and test ideas and to answer research questions. These include descriptive studies, experimentation, correlation, epidemiological studies, and serendipitous discovery. What many refer to as the "the scientific method" (testing a hypothesis through controlling and manipulating variables) is really a basic description of how *experiments* are done. As such, it should be seen as an important way, but not the only way, that scientists conduct investigations, as scientists can make meaning of the natural world using a variety of methodologies.

7. **Science is a social activity that possesses inherent subjectivity.** Science is a human endeavour, and as such, it is open to subjectivity. For example, the scientific questions considered worth pursuing, the observations that count as data, and even the conclusions drawn by

scientists are influenced to some extent by subjective factors. Such factors as the existing scientific knowledge, social and cultural contexts, external funding sources, and the researchers' experiences and expectations can influence how they collect and analyze data and draw conclusions from these data. While subjectivity cannot be totally removed from scientific endeavors, scientists strive to increase objectivity through peer review and other self-checking mechanisms.

These seven tenets of the nature of science present a more appropriate view of scientific knowledge and address the major misconceptions about science documented by science educators (Lederman et al., 2002; McComas, 1996). Taken as a whole, they serve as reminders that a principal strength of scientific knowledge is that it can change as needed and required to better fit existing data. However, it is important to realize that change in science is not arbitrary. Scientific knowledge changes only as a result of further inquiry, debate, collaboration, and evidence. Thus, changes in science move our understandings toward important "truths" about the natural world. Although these truths should not be viewed as absolute or final, they are among the most reliable that we have at any given point in time. No other means of inquiry has proven more successful or trustworthy. One need only consider the advances in science-related fields such as medicine, agriculture, and engineering, for verification that science works.

Why Teach the Nature of Science?

Science educators and researchers have presented a variety of rationales for teaching about the nature of science. Perhaps the most straightforward justification is that an accurate understanding of the nature of science helps students identify the strengths and limitations of scientific knowledge, develop accurate views of how science differs from other ways of knowing, helps students delineate the types of questions science can and cannot answer (Bell, 2008). Additionally, research suggests that teaching students the nature of science can enhance their content knowledge and increase student achievement (Cleminson, 1990; Songer & Linn, 1991). Furthermore, an appropriate understanding of the nature of science is essential to understanding the relationship between science and religion, the controversy over "creation science" and "intelligent design," and the essential differences between scientific and non-scientific disciplines (Matthews, 1997). Additionally, teaching the nature of science helps increase awareness of the influence of scientific knowledge on society (Driver, Leach, Millar & Scott, 1996; Lederman 1999; Meyling, 1997). Research also indicates that teaching the nature of science may increase student interest in science by making instruction more engaging and meaningful (Lederman, 1999; Meyling, 1997). Most importantly, developing appropriate conceptions of the nature of science is cited as a critical aspect of scientific literacy, and as such, is central to national standards documents (AAAS, 1993; NRC, 1996).

Transforming Science Teaching

Researchers have suggested that one innovative way to transform science teacher preparation and meet the needs of science education reform is to make connections between informal and formal science learning environments (McGinnis *et al*, 2012). Such informal science learning environment is usually seen as the cultural or community space of learning.

Rennie (2007) defined informal science education, in general, as the science learning that takes place in contexts outside of the formal school setting. Falk (2001) described this form of science learning as free-choice science learning, which is self-motivated, voluntary, guided by learners' needs, and engaged in throughout life. Valerie Crane (1994) defined informal science as "activities that occur outside the school setting, are not developed primarily for school use, are not developed to be part of an ongoing school curriculum, and are characterized by voluntary as opposed to mandatory participation as part of a credited school experience" (Crane 1994, p. 3). Such informal science learning occurs in a variety of contexts – and the one I chose to illustrate with is Hausa proverbs.

Ideally, researchers have identified a number of distinguishing features associated with informal learning: learning is voluntary and self-motivated (Rennie 2007; Rennie *et al*. 2003), the content is often nonsequential (Hofstein and Rosenfeld 1996), learning is socially constructed and guided by the learner's needs and interests (Falk 2001), and there is no formal assessment (Rennie 2007)

Learning science has become one of the most difficult challenges of the Nigerian educational system in recent years. This comes about because of the perception of the efficacy of science as a gateway to national development, which sees national governments spending more efforts in the teaching of science to children. Government policies, in both education and science, stress the need to produce more scientific manpower in order to make the nation progress and develop. It is overlooked in this policy zeal, that social development is a combination of so many factors – economic, political, social, and significantly, scientific – to truly achieve development.

Policy decisions, however, are only one perspective – the external perspective. Effective science learning requires effective science teaching. Being an effective science teacher entails much more than changing one or two variables and maintaining high expectations for the achievement of youth – or policy makers. Instead, as Teresi (2002) argued, effective teaching is complex, necessitating that teachers enact successful chains of interactions, not just for one person, or even one person at a time, but for a social network, producing and sustaining learning environments built upon fluent transactions.

Anthropologists such as Frank Boas have drawn attention to the fact an important aspect of culture is made up of the principles by which people classify their universe. It is such 'community classifications' that led to the development of the scientific disciplines we know. For instance, as explained by D'Amvrisio (2002) Science, as generally understood nowadays, emerged in a distinctive form of explaining, understanding and coping with the natural environment in the Mediterranean Basin, since early times.

This gives every culture an opportunity to develop what becomes science and quite adequate for its needs. In this context, therefore, it must be pointed out that science is not a collection of products, but a series of steps – in essence, a methodology. Ethonoscience, as a term came to be used by anthropologists in the 1960s and is often seen as the central fulcrum in understanding ethnoscience therefore is the creation of equivalency between folk beliefs – in terms of their oral traditions – and what is generally accepted as Western, 'conventional' science.

Proverbs as Folk Expressions

The wisdom of proverbs has guided people in their social interactions for thousands of years throughout the world. Proverbs contain everyday experiences and common observations in succinct and formulaic language, making them easy to remember and ready to be used instantly as effective rhetoric in oral or written communication. This has been the case during preliterate times, and there are no signs that proverbs have outlived their usefulness in modern technological societies either. Occasional claims persist that proverbs are on their way to extinction in highly developed cultures, but nothing could be further from the truth. While some proverbs have dropped out of use because their message or metaphor does not fit the times any longer, new proverbs that reflect the mores and situation of the present are constantly added to the proverbial repertoire.

There are literally thousands of proverbs in the multitude of cultures and languages of the world. They have been collected and studied for centuries as informative and useful linguistic signs of cultural values and thoughts. The earliest proverb collections stem from the third millennium B.C. and were inscribed on Sumerian cuneiform tablets as commonsensical codes of conductand everyday observations of human nature.

Of the various verbal folklore genres (i.e., fairy tales, legends, tall tales, jokes, and riddles), proverbs are the most concise but not necessarily the simplest form. The vast scholarship on proverbs is ample proof that they are anything but mundane matters in human communication. Proverbs fulfill the human need to summarize experiences and observations into nuggets of wisdom that provide ready-made comments on personal relationships and social affairs. There are proverbs for every imaginable context, and they are thus as contradictory as life itself.

The definition of a proverb has caused scholars from many disciplines much chagrin over the centuries. Many attempts at definition have been made from Aristotle to the present time (Kindstrand 1978; Russo 1983), ranging from philosophical considerations to cut-and-dry lexicographical definitions. The American paremiologist Bartlett Jere Whiting (1904–1995) reviewed many definitions in an important article on “The Nature of the Proverb” (1932), summarizing his findings in a lengthy conglomerate version of his own:

A proverb is an expression which, owing its birth to the people, testifies to its origin in form and phrase. It expresses what is apparently a fundamental truth—that is, a truism, —in homely language, often adorned, however, with alliteration and rhyme. It is usually short, but need not be; it is usually true, but need not be. Some proverbs have both a literal and figurative meaning, either of which makes perfect sense; but more often they have but one of the two. A proverb must be venerable; it must bear the sign of antiquity, and, since such signs may be counterfeited by a clever literary man, it should be attested in different places at different times. This last requirement we must often waive in dealing with very early literature, where the material at our disposal is incomplete. (Whiting 1932: 302).

A frequency study of the words contained in the over 50 definition attempts made it possible to formulate the following general description:

> A proverb is a short, generally known sentence of the folk which contains wisdom, truth, morals, and traditional views in a metaphorical, fixed and memorizable form and which is handed down from generation to generation. (Mieder 2004: 3).

Thus, as Tae-Sang (1999) argued, proverbs represent elements of traditional wisdom within a shared body of experience/knowledge/ethics of a given people, and they may summarize political, social, or other currently important issues within that community.

Hausa Proverbs as Ethnoscientific Methodology

So far I have looked extensively at what constitutes scientific methodology and why we teach science. I have also looked at proverbs as folk expressions. I want to end this discussion by giving a list of some 15 Hausa proverbs with scientific focus, so that we can see how, as science educators, we can combine elements of scientific methodology and folk sayings. Table 1 lists the proverbs and their possible scientific connotation within the broad area of a particular subject area.

Table 1 – A Sample of 15 Hausa Proverbs and their Scientific Implications

S/N	Proverb	Concept	Domain
1.	***Zama da Maɗaukin Kanwa Shi ke Kawo Farin Kai***	Communicable Diseases	Biology
	Staying with a potash carrier can deposit white powder on your head (acquiring a habit from someone with the same habit)		
2.	***Hali Zanen dutse***	Heredity	Biology
	Your behavior is etched in stone (you are what you are)		
3.	***Barewa ta yi gugu ɗanta yayi rarrafe?***	Genetics	Biology
	The offspring of a gazelle must be as fast as the mother (acknowledging brilliance of children as being from parents)		
4.	***Harbi ga ɗan Jaka Gado ne***	Heredity	Biology
	Kicking out is heridatory to a the offspring of a donkey (acknowledge prowress in children)		
5.	***Biri Yayi Kama da Mutum***	Evolution	Biology
	Really a monkey resembles a human (explaning bad behavior)		
6.	***Hankali ke Gani Ba ido ba***	Sense Organs	Biology
	Use your senses to judge, not your eyes		
7.	***Da Rarrafe kan Tashi***	Growth and Development	Biology
	Crawl first, before walking		

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S/N	Proverb	Concept	Domain
	(graduation process in evolution)		
8.	***Kamar an tsaga Kara***	Heredity	Biology
	Like peas in a pod (resemblance, e.g. twins)		
9.	***Ba a yabon ɗan Kuturu sai ya girma da Yatsa***	Genetics	Biology
	You are never sure of leper's son till he grows with full limbs (caution about apparent good behaviour of a child)		
10.	***Ruwa baya Tsami Banza***	Water Pollution	Chemistry
	Water does not spoil without a reason (indicating an improper behavior in an otherwise normal person)		
11.	***Allah ne yasan Barcin Makaho***	Observation	General Science
	Only God knows when a blind man is sleeping (be sharp at all times, for things are not what they often seem)		
12.	***Komai nisan Dare Gari zai waye***	Sunrise/sunset	Geography
	No matter how long the night, dawn will come (we live with hope)		
13.	***Alamar ƙarfi tana ga Mai Ƙiba***	Momentum	Physics
	Obesity is a sign of strength (assumes the appearance of things is what makes them faster or stronger)		
14.	***Yaro bai san wuta ba sai ya taɓa***	Heat Energy	Physics
	A child does not know how hot fire is, until he is burned when		

S/N	Proverb	Concept	Domain
	touching it (cautions aganst impulsive actions)		
15.	***Komai nisan Gari Akwai wani Gaban sa***	Acceleration	Physics
	No matter how far a city is, there is always another city ahead of it (speed, motion)		

CONCLUSION

Science is more than a body of knowledge and way of developing and validating that knowledge. Science is a social activity that reflects human values, including curiosity, creativity, integrity, and skepticism. Developing scientific literacy requires meaningful, engaging instruction that integrates the knowledge of science, the methods of science, and the nature of science. Scientific inquiry as both content and as a process for learning provides opportunities for students to develop inquiry skills, use critical thinking, and deepen their understanding of science content. Further, research strongly supports our experience that students enjoy the challenges of scientific inquiry when given appropriate support, and that they are enthusiastic participants in learning about the nature of science and how we know what we know. Teaching the nature of science and inquiry encourages students to develop scientific habits of mind that will enable them to be effective decision-makers beyond the classroom. Folk science in the form of ethnoscience is one such way of facilitating such effective decision-making among children.

REFERENCES

Abd-El-Khalick, F., Bell, R., & Lederman, N. (1998). The Nature of Science and Instructional Practice: Making the Unnatural Natural. *Science Education*, 82, 417-437.

Bell, R.L. (2008). *Teaching the nature of science through process skills: Activities for grades3- 8*. New York: Allyn & Bacon/Longman.

Boas, F. (1911). Introduction, in *Handbook of American Indian languages*. Washington: G.P.O.

Crane, V. (1994). An introduction to informal science learning and research. In: V. Crane, H. Nicholson, M. Chen, & S. Bitgood (Eds.), *Informal science learning: What the research says about television, science museums, and community-based projects* (pp. 1–14). Ephrata, PA: Science Press.

Driver, R., Leach, J., Millar, R., & Scott, P. (1996). *Young people's images of science*. Philadelphia: Open University Press.

Falk, J. H. (2001). Free-choice science learning: Framing the discussion. In J. H. Falk (Ed.), *Freechoice science education: How we learn science outside of school* (pp. 3–20). New York: Teachers College Press.

Lederman, N.G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching*,29, 331-359.

Lederman, N.G. (1999). Teachers understanding of the nature of science and classroom practice: Factors that facilitate or impede the relationship. *Journal of Research in Science Teaching*, 36, 916-929.

Lederman, N.G. (2007). Nature of science: past, present, and future. In S.K. Abell & N.G. Lederman (Editors), *Handbook of research on science education* (pp. 831-880). Mahwah, NJ: Lawrence Erlbaum Associates.

Lederman, N.G., Abd-El-Khalick, F., Bell, R.L.,& Schwartz, R.S. (2002). Views of nature of science questionnaire (VNOS): Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching*, 39, 497-521.

Luft, J., Bell, R.L., & Gess-Newsome, J. (Eds.) (2008). *Science as Inquiry in the*

Secondary Setting. Arlington: National Science Teachers Association Press.

Matthews, M.R. (1997). Editorial, *Science & Education*, 6, 323-329.

McComas, W. (1996). Ten myths of science: Reexamining what we think we know. *School Science & Mathematics*, *96*, 10-16.

McGinnis, J. Randy et al (2012). Informal Science Education in Formal Science Teacher Preparation. In Fraser, B. J., Tobin, K. G., & McRobbie, C. J. (2012). *Second international handbook of science education* (pp. 1097-1108). Dordrecht: Springer.

Meyling, H. (1997). How to change students' conceptions of the epistemology of science. *Science & Education*, 6, 397-416.

Mieder, W. (2004). *Proverbs: A Handbook*. Westport, Connecticut: Greenwood Press

Osborne, J., Collins, S., Ratcliffe, M., Millar, R. & Duschl, R. (2003). What "ideas-about-science" should be taught in school? A Delphi study of the expert community. *Journal of Research in Science Teaching*, 40, 692–720.

Peters, E. E. (2009). Shifting to a student-centered science classroom: An exploration of teacher and student changes in perceptions and practices. *Journal of Science Teacher Education*. Available online: http://www.springerlink.com/content/t1r9620275t82502/fulltext.pdf

Rennie, L. J. (2007). Learning science outside of school. In S. K. Abell (Ed.), *Handbook of research on science education* (pp. 125–170). Mahwah, NJ: Lawrence Erlbaum.

Rennie, L. J., Feher, E., Dierking, L. D., & Falk, J. H. (2003). Toward an agenda for advancing research on science learning in out-of-school settings. *Journal of Research in Science Teaching, 40,* 112–120.

Songer, N., & Linn, M. (1991). How do students' views of science influence knowledge integration?

Journal of Research in Science Teaching, 28, 761-784.

Tae-Sang, J. (1999). A Poetic Structure in Hausa Proverbs. *Research in African Literatures*, Vol. 30, No. 1 (Spring, 1999), pp. 83-115.

Teresi, D. (2002). *Lost discoveries: The ancient roots of modern science-- from the Babylonians to the Maya*. New York: Simon & Schuster.

Tobin, K. (2012). 'Sociocultural Perspectives on Science Education', In: Fraser, B. J., Tobin, K. G., & McRobbie, C. J. (2012). *Second international handbook of science education* (pp. 3-18). Dordrecht: Springer.

Whiting, B. J. (1932). "The Nature of the Proverb." *Harvard Studies and Notes in Philology and Literature* 14: 273–307; also in Whiting 1994: 51–85.