



# Exploring Indigenous Game-based Physics Activities in Pre-Service Physics Teachers' Conceptual Change and Transformation of Epistemic Beliefs

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## ABSTRACT

*Laro-ng-Lahi* (Indigenous Filipino game) based physics activities invigorated the integration of culture in the pre-service physics education to develop students' epistemic beliefs and the notion of conceptual understanding through conceptual change. The study conveniently involved 28 pre-service undergraduate physics students enrolled in an introductory physics course in a Philippine university. Context-culture-based framework dictated how the traditional Filipino games blend with Newtonian concept formation to motivate conditions and conceptual ecology for conceptual change to occur. These physics activities conducted by the participants in each session directed their explicit learning of Mechanics concepts. Pre-post-test design using the Force Concept Inventory and Epistemological Beliefs Assessment for Physical Science detected the participants' conceptual change and epistemic beliefs improvement respectively. Qualitative data from student interviews and journal insights supplemented the quantitative data. Results showed that these physics activities indicated significant change in the students' conception interpreted as conceptual change. The study also indicated incremental development of epistemic beliefs, however, the progress observed was not statistically significant. Consequently, it is recommended that sustained and prolonged exposure of pre-service undergraduate physics students to culture-influenced instructional designs may lead to eventually developing sophisticated epistemic belief systems consequently providing better teaching and learning framework and service for quality education.

**Keywords:** conceptual change, context-based approach, epistemological beliefs, *Laro-ng-lahi*

## INTRODUCTION

Many students perceive physics to be difficult despite different interventions. Literature (Angell, Guttersrud, Henriksen & Isnes, 2004; Barmby & Defty, 2006; Lavonen, Meisano, Byman, Uiito & Juiit, 2005; Williams, Stanisstreet, Spall, Boyes, & Dickson, 2003) suggests that students generally discriminate against physics as conceptually hard, abstract, and uninteresting that only exceptionally gifted and talented students appreciate and survive the

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### **State of the literature**

- Physicists and educators alike have been analyzing different aspects of learning to address student difficulty in the course termed as misconceptions and naïve concepts. They explored the field of cognition that led to the notion of conceptual understanding through conceptual change. Some experts quantified these difficulties through concept assessments while others believed that attitude and epistemologies of learners are vital in the analysis.
- Teacher quality is an identified factor in developing both concepts and epistemic beliefs, thus, producing quality teachers means ensuring quality education.
- An emerging literature, however, presents the socio-cultural theory applied in physics education to develop pre-service.

### **Contribution of this paper to the literature**

- This paper provides a fine link between culture and physics education through traditional Filipino games emphasizing socio-cultural theory applied in pre-service physics education to develop both conceptual understanding through conceptual change and epistemological belief systems of pre-service physics teachers.
- Provides means to integrate culture and tradition of the learner in learning content science courses such as physics to address student difficulty.
- Affords inputs to pre-service physics education curricula for more quality physics teachers.

course. However, educators firmly believe that students learn best and achieve in physics if they find the course understandable (Gebbers, Evans, & Murphy, 2010). In addition, these authors claimed that students' perception in physics influences their understanding, learning of that course, and probably excellence in the subject. Educators (Darling-Hammond, 2000; Marzano, 2007) reported that excellence in physics depends foremost on teacher quality. Accordingly, Marzano (2007) recounted that without a well-educated, strongly-motivated, skilled, well-supported teacher, the arch of excellence in learning physics collapses. This idea was supported by the findings of Adeyemo (2012) who emphasized that teacher quality is an important input in effective learning leading to quality output. Similar research findings on quality teacher were reported early on by Ferguson (1992), Ogunmiyi (2001), Sanders (1988), and Wenglinsky (1992).

Agusibo (2008) described quality teacher as a trained teacher who can translate school curriculum into vivid reality and positively impact on student academic achievement. Specifically, Adeyemo (2012) identified that the teacher's roles to excellence in physics include choosing the strategy, designing lesson, and implementing the most suitable teaching methodology using the most appropriate laboratory facilities and tools. Thus, the success of students in physics considerably depends on proper interaction between the teacher, the students and the materials for teaching and learning the course. In this regard, Nelson (2006) qualified this state of teacher's role as the fourth generation of evolutionary framework of generations of instructional change that involves an approach embracing teacher collaborative learning communities. Apparently, with the advent of new curricula in the basic education

advocating the K-12 framework, the preparation of physics teachers entails a lot of effort to produce effective teaching of physics that includes using strategies to promote constructivist learning, conceptual understanding of physics topics and to develop skills and methods for students to understand the processes of scientific inquiry.

### **Preparing for Quality Teacher**

A closer look into science teacher preparation (Nelson, 2006) is deemed necessary to support students to achieve the standards and help them attain excellence. Physics Education Research (PER) has long been exploring different areas of content and pedagogy for better physics teacher preparation. Recent studies (Conley et al., 2004; Kang & Wallace, 2005; Brownlee et al., 2009) explored the link between pre-service teachers to epistemological beliefs. This is a currently nurtured research area grounded on research findings (Bolhuis & Voeten, 2004; Bruning, Schrew, Norby, & Ronning, 2004; Olafson & Schraw, 2002, 2010; Tsai, 2007; Yang et al., 2008) that teachers' epistemological beliefs are related to the teacher's types of classroom instructional strategies and approaches. Olafson and Schraw (2010) confirmed this claim in their findings that epistemological beliefs are viewed as influential factors in the classroom. These factors that include: 1) how teachers choose their teaching strategies; 2) how they choose their teaching materials; 3) how they might accept education reforms; and 4) how they view how professional development affect classroom teaching practices.

In the Philippine pre-service physics education, its Commission on Higher Education (CHED) designed the curriculum around three major domains (CHED, 2004): 1) general education (foundational knowledge); 2) professional education (theoretical knowledge about teaching and learning, methodical skills, professional and ethical values, and experiential knowledge and skills); and 3) specialization education (subject matter knowledge). This scheme dictated the pre-service education in the country until the move to a K-12 program posed several challenges directing a curricular shift to an outcome-based teacher education curriculum (OBTEC). This new curricular paradigm in pre-service education that engulfs the physics teacher education field features learning outcomes rather than learning competencies to ensure developing quality physics teachers.

The crafted teacher training curriculum in OBTEC framework may be best achieved through the aforementioned curricular design supplemented with specific details of holistic teacher development that includes not only cognitive, affective, and psychomotor aspects but also epistemological beliefs.

Beliefs about knowledge and learning is assumed by Magno (2011) to influence learners' approach in dealing with and constructing information. Furthermore, several researchers (Muis, 2004; Schommer, 1990; Schrommer, Crouse & Rhodes, 1994) supposed that epistemological beliefs are indicative of numerous constructs of academic performance such as comprehension, meta-comprehension, interpretation of information, higher order thinking skills, persistence in working on different academic tasks and problem-solving approaches which may help shape quality teachers. These traits and skills necessary to quality learning

are of profound interest to bring about optimal teaching-learning outcome and address identified basic problems in teaching and learning such as those experienced by pre-service teachers shifting to and implementing complex learning in their classroom practices (Bernardo, 2008). He further claimed that these difficulties stem from students' exposure to the Philippine education system that focus on "simple learning," where Filipino instructors created "simple" lesson plans and taught them with "minimal effort" by employing simple and light forms of classroom discussion and activities. Filipino students may be taught with complex concepts only if the teachers' epistemological beliefs, which basically guide how they teach subjects in school (Bernardo & Calleja, 2005) are properly harnessed in their pre-service undergraduate education.

### **Developing Epistemic Beliefs**

Personal epistemologies as most researchers (Bendixen & Rule, 2004; Huling, 2014; Loyens, Rikers, & Schmidt, 2009) confirm, develop over time in a constructivist manner. They theorized that beliefs about learning may be a pioneer to one's own belief and that conceptions of knowledge develop progressively through educational experiences. In general, Philipps (2001) reported that most pre-service teachers have simple and naïve beliefs, which are highly influenced by their experiences with traditional teacher and instruction before they enter the university. If these naïve beliefs persist, pre-service teachers will tend to regard learning as repetition and rehearsal of isolated pieces of information (Kang & Wallace, 2005). But, Brownlee et al. (2009) supposed that if pre-service teachers think that knowledge is uncertain and evolving, then they will more likely deduce deeper meaning of what they read and learn. These deductions led Braurer & Wilde (2014) to recommend that stronger emphasis be provided on changing the epistemological beliefs of pre-service teachers during their academic training to improve science teaching.

### **Relating Epistemology and Culture**

How else can a university provide for the developmental improvement of epistemological beliefs of pre-service teachers? A number of studies (Banks, 1993; Lixin, 2006; Liu, 2009; Samarov & Porter, 2004;) for instance, found that cultural dimensions of learners distinguish student learning characteristic and even correlate with knowledge construction of students. Intertwining this research field with the frameworks of beliefs may lead to the demanded quality teachers. Researchers (Bernardo, 2008; Chan & Elliot, 2004; You, Yang & Choi, 2001) who initiated these studies focused on epistemological beliefs conducted through cross-cultural studies. Beliefs on the nature of knowledge and nature of knowing were disputed to be culturally-specific particularly comparing the Western and the Asian educational systems. As an extension of their work, Morales (2014) correlated the Filipinos' cultural dimensions and their respective epistemological beliefs. She found that Filipinos' cultural inclinations such as rare individual initiatives; teachers' focus on individual rather than on groups; students' association of self to pre-existing groupings; and focus on learning to do positively related to their view of physics and chemistry concepts as bits and pieces, weakly

connected concepts, if not just bunch of facts and formulas that highly influenced their individualistic preference. Furthermore, she found that cultural inclination of Filipino learners to individualism goes with their belief that scientific ways of thinking is only applicable in restricted spheres such as the classroom or laboratory. She also recommended that intertwining the idea on learners' epistemological belief and their cultural inclination may establish certain design of meaningful and effective curriculum. With the same intentions of achieving quality teachers through improving pre-service education, the study aims at developing the pre-service conceptual understanding in the context of conceptual change and enhancing their epistemic beliefs systems using unique culture-tradition-influenced learning materials to achieve meaningful learning.

## LITERATURE REVIEW

### Epistemological Beliefs

The Physics Education Research (PER) community has an emergent body of study devoted to investigating several known themes that include student's belief systems and conceptual change. Particularly, Chan and Elliot (2000) identified that this line of investigations relate to relationships between learning and the beliefs students hold about the nature of knowledge and the process of acquisition. These set of beliefs are referred to as epistemological beliefs, first studied by Perry (1968), and who suggested that students go through stages of development in sequential and linear manner. Consequently, Ryan (1984) grounded his work on the outputs of Perry that developed a dualism scale and tried linking epistemological beliefs to students' academic performance. Further developments in this field of research led to various theoretical models used to conceptualize personal epistemology: developmental models, cognitive models, multi-dimensional models, resource models, and domain specific models.

- *The uni-dimensional developmental model* (King & Kitchener, 2004), in which Kuhn (1991) viewed epistemological beliefs as sequence of positions that differ from each other takes in nine positions moving from a dualistic or absolutist view of knowledge and learning to a more relativistic view which ends in commitment and willingness to adopt a position while understanding that new information may cause one's position to change.
- Evolving from developmental theories, *cognitive theories*, describe a sequence of phases that progress from absolutist to relativistic thinking shown in the responses to questions designed to assess student reasoning processes when presented with a problem (King & Kitchener, 2002; Kuhn, 2001; Kuhn & Weinstock, 2002). Previous research conducted by Hofer and Pintrich (1997) provided two major categories of epistemological beliefs: the "nature of knowledge" and the "nature of knowing." Following Hofer's and Pintrich's study, Conley, Pintrich, Vekiri, and Harrison (2004) further classified epistemological beliefs into four categories: source, justification, certainty and development. Accordingly, source and justification reveal beliefs about

the nature of knowing while certainty and development involve the nature of knowledge.

- Schommer's (1990) *Multidimensional approach* regards various dimensions as independent of each other. Her theory provided five dimensions: 1) source of knowledge – from knowledge as handed by authority to knowledge reasoned out through objective and subjective means; 2) certainty of knowledge – from knowledge being absolute to knowledge that is constantly evolving; 3) organization of knowledge – from knowledge being compartmentalized to knowledge as highly integrated; 4) control of learning – from ability to learn as genetically determined to ability to learn is acquired through experience; and 5) speed of learning – from learning thought of to be quick or not at all to learning is a gradual process.
- Merging these two contrary categories about epistemological beliefs, Hammer and Elby (2002) proposed *epistemological resources* (units of cognitive structure) as alternate conceptualization of personal epistemology to both developmental and multi-dimensional theories. Specifically, Elby's and Hammer's major contribution is the questioning of consensus regarding what comprises sophisticated epistemology, which views personal epistemology as tentative, evolving, socially, and culturally constructed rather than certain, unchanging, and discovered.

Considerably, Schommer-Aiken's and Duell's (2013) study found that beliefs are activated depending on the contexts which may either be *domain-specific* or *situation-specific*. They also proposed that the development of beliefs is influenced by the amount of knowledge or expertise. Results of empirical studies (Buehl et al., 2002; Hofer, 2000; Schommer & Walker, 1995) show that discipline-based beliefs led them to develop specific measures of domain-specific beliefs. Hofer, in 2002, designed the Discipline-Focused Epistemological Beliefs Questionnaires. Buehl et al. (2002) constructed the Domain-Specific Belief Questionnaire. Others also believed that designing questionnaires in specific disciplines such as the Epistemological Beliefs Assessment for Physics Science by Elby (1999), which probes students' views along the five non-orthogonal dimensions: structure of knowledge, nature of knowing and learning, real-life applicability, evolving knowledge, and source of ability to learn; better deduce students' epistemologies.

### **Epistemological Beliefs in Science Education Context**

Sharma, Ahluwalia, and Sharma (2013) defined epistemology as the branch of philosophy that deals with the study of knowledge and beliefs. According to them, epistemology in science context deals with the nature of science and scientific knowledge by raising questions such as: 1) how do we know what we know; 2) how do we create new knowledge; 3) how do we draw inferences; and 4) how do we make sense. Several research found that student's epistemological beliefs have great influences on their approaches to learning. In fact, May and Etkina (2002) claim that when it comes to learning physics concepts, students' epistemology matters. Creating learning environments that will develop the belief systems of students to favorable ones may bring about better knowledge on learning. This

connection of students' beliefs to learning highlights the science teacher's roles and models science teacher preparation or pre-service education to achieving good and expert-like belief. Such linkage is grounded on several research findings (Chan, 2004; Claderhead & Robson, 1991; Hollingsworth, 1989; Tillema, 1995) that teachers' epistemological beliefs influence their choices and decisions in the classroom such as how the teacher manages the class and what to focus in learning. Chan (2004) even concluded in her study that teachers' conceptions and class teachings are beliefs driven. She recommended that teacher education programs should promote developing epistemologies of pre-service teachers to better their conceptions of learning and teaching because student- teachers' epistemological beliefs influence their ideas on learning and eventually, their preferences for a certain way of teaching. The same areas of research were explored and confirmed by many educators (Olafson & Scraw, 2010; Walker, Brownlee, Whiteford, Exely& Woods, 2012; White 2000).

As aforementioned, Bernardo and Calleja (2005) found out that in the Philippines, epistemology of learning was basically guided by how educators taught subjects in schools. Bernardo (2008) even distinguished that Filipino pre-service teacher's experienced difficulty in shifting to and implementing complex learning in their classroom practices since they had always been exposed to the Philippine educational system concentrating on "simple learning." He further concluded that Filipino pre-service teachers take into consideration their beliefs, values, and feeling as they evaluate which options will bring about optimal teaching-learning outcome.

### **Influence of Culture on Learning**

Cultural context learning, according to research (Banks, 1993; Lixin, 2006; Liu, 2009; Samarov and Porter, 2004) connects with students' meaning making and knowledge construction. Culture, as recounted by Samarov (2004) affects the way we distinguish and process the world. This observation was concretely observed by Morales (2015) as improvement of concept attainment of her students when she integrated culture in learning physics. She reasoned that in this scheme, learners appreciate physics as something that would supplement the knowledge of their roots and their daily decision making activities. Equally, this culture-influenced leaning situated within the paradigm of context-based learning emphasized culture as the context and lies within the line of study of several research and projects such as Rekindling Tradition (Aikenhead, 2001) and Outdoor Physics (Popov, 2008).

Within culture are sets pre-given as language, notions of identity, gender, nature and religion. Pertierra (2002) further described culture as an invisible lens through which we see reality. This can also be a set of ideas, values, and practices as well as orientation and predisposition towards the world which can be categorized as tangible such as tools and technology or non-tangible like beliefs, practices and traditions which among others include the national games.

In the Philippines, national or traditional games popularly termed as *Laro ng Lahi*, are described as a compilation of local games practiced in the country and are indigenous games

commonly played by Filipino children, where they use locally available materials or instruments (Aguado, 2012). Lopez (1980) identified some common *Laro-ng-Lahi* as dock on a rock game (*tumbang preso*), block the enemy game (*patintero*), gillidanda (*syato*), leap frog (*luksong baka*), tag of war (*hilaang lubid*), rubber band game (*dampa*), and marble game (*holen*). Accordingly, Lopez defined 'Laro', a Filipino term as all forms of recreational play and described 'palaro' as games that take place during parties, festivals and town fiestas. Barbosa (2003) referred to the latter as competitive in nature where each stretch is always brought to a conclusion. These games are considered as Filipinos' index of sociability - a reason for them to like these games as they bring members of the family together after their respective chores that strengthen ties to bind families (Lopez, 2001). In adult education, Fiagoy (2000) cited the use of games for practice, contextualized within the culture and experiences of the Filipinos. Furthermore, these traditional or indigenous games are identified as ways to acquire proper sports techniques in preparation for greater or competitive participation in selected sports and recreational activities.

Backtracking, Philippine national games were part of the physical education (P.E.) curriculum in all levels of education and sport activities of the local government units, through Senate Bill 1108 and House Bill 2675. These bills supported the mandates of the 1987 Philippine Constitution to conserve, promote, and popularize the nation's historical and cultural heritage and resources to preserve them for future generations of Filipinos to ensure continuity of our identity and cultural belongingness. Currently, the Department of Education (DepEd) implemented Section 14, Article XIV of the 1987 Philippine Constitution which highlights fostering the preservation, enrichment, and dynamic evolution of a Filipino national culture based on the principle of unity in diversity in a climate of free artistic and intellectual expression through advocating *Laro ng Lahi* in physical education curricula.

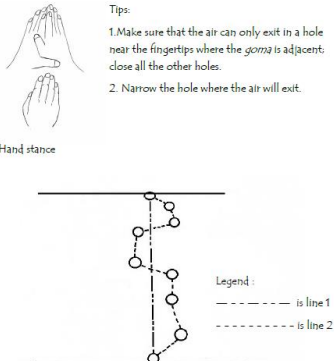
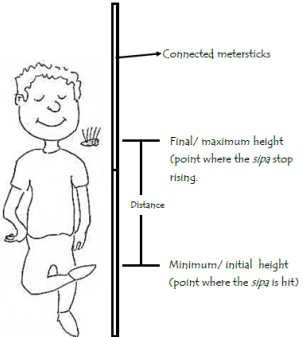
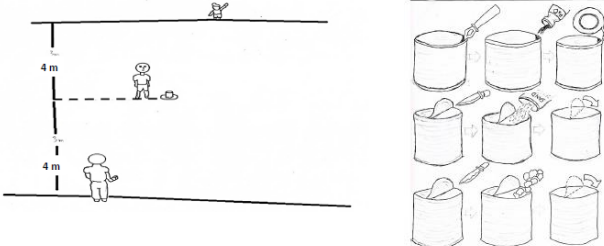
As detailed on these bills, traditional games and sports are played in the various localities in the country. These local games, as claimed by Fine (1995), can thread and sew the learning situations into the fabric of national life. Interconnecting these games with real-life situations becomes the true definition of holistic learning, and together we become a "community of inquirers" supporting alternative life choices for all students and working collectively to speak out, be heard and effect change. Descriptions of these traditional games provided in **Table 1** may afford valuable insights on how these physical activities or games may connect with physics concepts.

### **Context-based learning in Pre-service Physics Education**

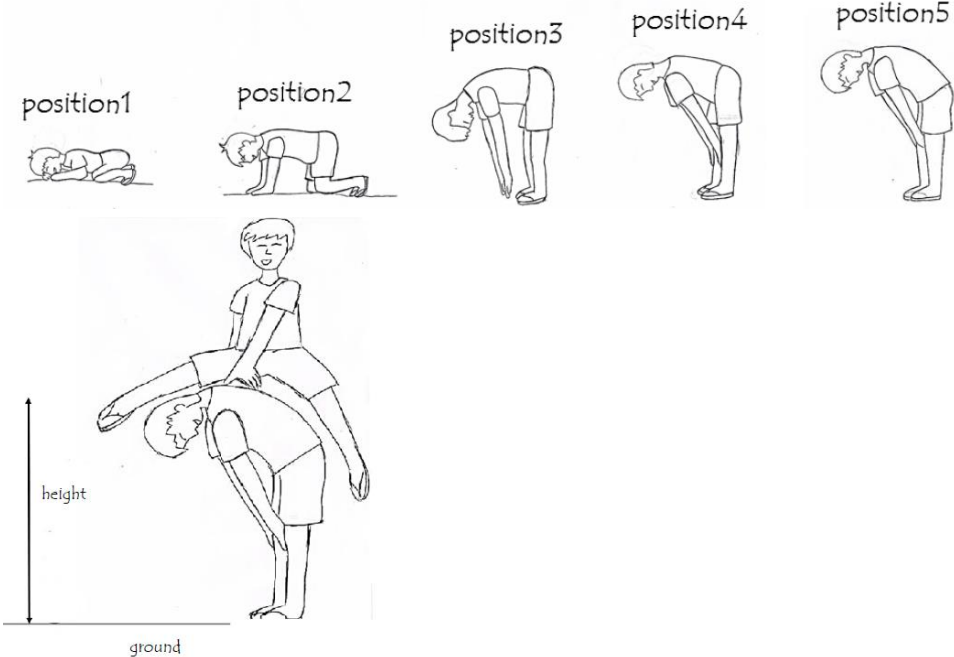
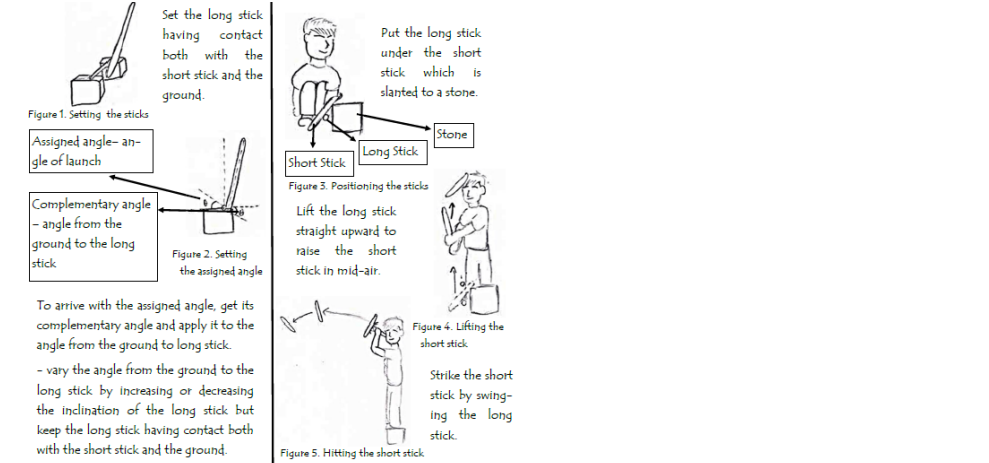
Many believe that experienced-based and concrete-real life examples in teaching physics entice learners and challenge their prior knowledge possibly leading to meaningful learning with a challenged conception. Campbell et al. (1994) first introduced real-life connections in science as Salter's approach; to address science education issues such as scientific literacy, public understanding of science, and less and less students wanting to take up science in A-level. This approach aimed to set science in context to motivate more students to study science.



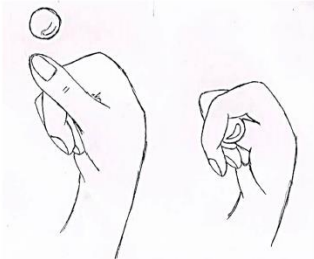
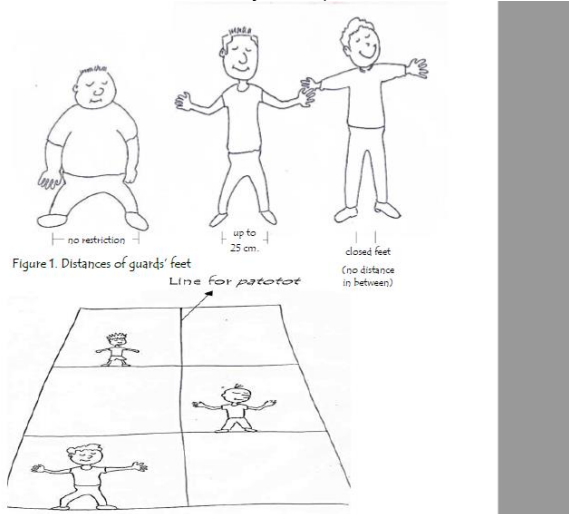
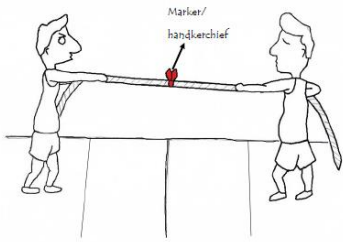
**Table 1.** Traditional Filipino Games vis-à-vis the Mechanics topics

Game and Concept	Description
<p><b>Dampa</b> (Distance and Displacement)</p>	<p>Dampa is played with “goma” (rubber band), often comes with different colors. It is the action of tapping the ground where compressed air is formed and released causing the “goma” to move. There are different hand stances that can be used in playing and one can use any stance.</p>
	 <p>Tips:</p> <ol style="list-style-type: none"> <li>1. Make sure that the air can only exit in a hole near the fingertips where the <i>goma</i> is adjacent; close all the other holes.</li> <li>2. Narrow the hole where the air will exit.</li> </ol> <p>Figure 1. Hand stance</p>
<p><b>Sipa</b> (Acceleration due to Gravity, Work-Energy Theorem)</p>	<p>Sipa is the local counterpart of “Sepak Takraw,” previously known as the national game of the Philippines. It can also refer to the game, the object being hit, or the action of hitting. A “sipa” is a shuttlecock-like toy made from a one-inch lead washer with the tail-end made from plastic straw rope. To play this traditional game, the player use his/her foot, knee, elbow, or hand to continuously hit the “sipa.” This game tests the agility, speed, and control of the players.</p>
	
<p><b>Tumbang Preso</b> (Laws of Motion)</p>	<p>“Tumbang Preso” originated in the Tagalog region and is best played with not more than nine players. This game is played using an empty tin can which is targeted by the players using a “tsinelas” (rubber slipper). The aim of the player is to topple the empty can by throwing a rubber slipper on it. Variations can be done by filling-in the can with sand content.</p>
	

**Table 1.** Traditional Filipino Games vis-à-vis the Mechanics topics (*continued*)

Game and Concept	Description
<p><b>Luksong Baka (Kinetic and Potential Energy)</b></p>	<p>Luksong Baka is said to originate from a province in the northern part of the country. It is a variation of "luksong tinik" (leap frog version of the Filipinos), where players jump over hands and feet of two "it." In luksong tinik, players jump over the person who are positioned from tucking on the ground up to almost standing straight, only neck is bowed down.</p> 
<p><b>Shato (Projectile)</b></p>	<p>This game is similarly played in India as Gilli Danda. The hitter flings the short stick (kalawit) using the longer stick for the offensive team, while the catcher catches the short stick in mid-air [defensive team].</p>  <p>Set the long stick having contact both with the short stick and the ground.</p> <p>Put the long stick under the short stick which is slanted to a stone.</p> <p>Lift the long stick straight upward to raise the short stick in mid-air.</p> <p>Strike the short stick by swinging the long stick.</p> <p>To arrive with the assigned angle, get its complementary angle and apply it to the angle from the ground to long stick.</p> <p>- vary the angle from the ground to the long stick by increasing or decreasing the inclination of the long stick but keep the long stick having contact both with the short stick and the ground.</p>

**Table 1.** Traditional Filipino Games vis-à-vis the Mechanics topics (*continued*)

Game and Concept	Description
<b>Holen (Elastic Collision)</b>	<p>Holens, also called marbles, are used to play "holen" where the objectives of the game is to hit the opponent's marble or marbles inside a drawn circle. To come up with best result, tuck the marble with your middle finger, the thumb under the holen, and use index finger to stabilize the holen.</p> 
<b>Patintero (Balance and Stability)</b>	<p>Also known as "Harangang Taga" and "Tubigan" and translated as "Block the Enemy Game." The players are grouped as offensive team or the passers and the defensive team as the line guards. The objective of a team is to accumulate as many points by passing the lines without being tagged. Passers are supposed to cross the lines from the starting point and back. Four line guards are positioned on the vertical line and one on the horizontal line of the court. Their feet must always be on the line. Line guards tag the passer with powered hands. If any of the passer is tagged, the line guard immediately assumes the position of passer even if the two-minute time limit has not yet elapsed.</p> 
<b>Hilahang Lubid (Translational Equilibrium)</b>	<p>Hilahang Lubid is also known as "culliot." There are variations of this game where the losers will fall on mud. Known as "Tug of War," sounds a game meant for alpha male. This game is seen as test of strength.</p> 

It also provides students with a more authentic picture of science, and of its role in people's lives, and to encourage them to connect science learning with the rest of their lives. Researches (Whitelegg & Parry, 1999) considered context-based learning as a way of using real world arguments or controversial issues, often social issues, for students to discuss. In 2005, Yam reported that context-based learning and teaching help teachers relate subject matter content to the real world situations. Accordingly, this style motivates students to make connections between knowledge and its applications to their lives as family members, citizens, students or children, and workers. Furthermore, Morales (2015) cited that contextual teaching and learning strategies underscore problem-solving skills; recognize the need for teaching and learning to occur in a variety of contexts such as home, community, and work sites; facilitate student monitoring and directing of their own learning as self-regulated learners; link teaching to diverse life-contexts; use teams or interdependent group structures to encourage students to learn from each other and together; and implement authentic assessment.

Context-based learning has been applied to science education in many projects - *ChemCom*, *PLON*, *Salter's Science*, *ChemieimKontext* and *PhysikimKontext*. Kortland (2007) reported that these projects provide practical applications and/or socio-scientific issues at the start of the teaching-learning of science to bridge the gap between the often abstract and difficult science concepts and the world the students live in. Currently, context-based learning and teaching approach took several strands such as problem-based and product-based assessment (Yam, 2005); game-based approach (Jones, Caton, & Greenhill, 2014), technology-based approach (Van Joolingen, deJong, & Dimitrakopoulout, 2007), and socio-cultural-based approach (Arroio, 2010). To date, context-based learning continuously evolves to help address perennial issues of student difficulty and probably address global issues such as conceptual change and scientific literacy.

With all the aforementioned learning theories and research findings, a way to achieve quality physics teaching can be done through a good pre-service physics education aimed at developing epistemologies and conceptual understanding of pre-service undergraduate physics students through cultural learning. Culture-based context learning may be able to attain this goal. In this study, traditional Filipino games are seen as potential context for culture-game-based physics education. This context may promote physics in action as when these traditional games are developed into physics activities, which served as support materials to the country's new curriculum and help improve pre-service students' conceptual understanding in physics and epistemological beliefs, which may eventually concretize how to teach the course with quality.

## PURPOSES OF THE RESEARCH

The study sought to explore how culture-based, particularly traditional or local-game-based learning of physics utilizing physics activities designed using Filipino traditional games affect the conceptual change and epistemological beliefs of pre-service physics teachers in the Philippines. Specifically, the study sought answers to the question: How effective is culture-

game based teaching and learning utilizing physics activities designed using Filipino traditional games in developing: a) conceptual understanding and b) epistemological beliefs of pre-service physics teachers?

The theoretical underpinning of this study also includes the following: 1) Elliot's and Chan's (2000) research findings that epistemological beliefs influence teachers' disposition, choices, and decisions inside the classroom; 2) Chan's (2004) and others researchers (Zhu, Valcke & Schellens, 2008) report rallying about the significance of epistemological beliefs in teacher education and its development as influenced by culture and cultural learning; and 3) Lam's and Chan's (2008) with Stathopoulou's and Vosnaidu's (2007) positive correlation result between conceptual change and epistemological beliefs.

### Epistemological Beliefs in Physical Sciences

Epistemology, as defined by Phan (2006), is a branch of philosophy concerned with the nature of knowledge and justification of beliefs. These are held beliefs about nature, nature of science and the validation of students' beliefs described in the five dimensions of beliefs: stability of knowledge, structure of knowledge, source of knowledge, malleability of knowledge, and speed of learning. Elby's (1999) Epistemological Beliefs Assessment for Physical Sciences (EBAPS) provides analysis of students' views along five non-orthogonal dimensions:

- *Structure of scientific knowledge.* Is physics and chemistry knowledge a bunch of weakly connected pieces without much structure and consisting mainly of facts and formulas? Or is it a coherent, conceptual, highly-structured, unified whole?
- *Nature of knowing and learning.* Does learning science consist mainly of absorbing information? Or, does it rely crucially on constructing one's own understanding by working through the material actively, by relating new material to prior experiences, intuitions, and knowledge; and by reflecting upon and monitoring one's understanding?
- *Real-life applicability.* Are scientific knowledge and scientific ways of thinking applicable only in restricted spheres, such as a classroom or laboratory? Or, does science apply more generally to real life?
- *Evolving knowledge.* This dimension probes the extent to which students navigate between the twin perils of absolutism (thinking all scientific knowledge is set in stone) and extreme relativism (making no distinctions between evidence-based reasoning and mere opinion).

*Source of ability to learn.* Is being good at science mostly a matter of fixed natural ability? Or, can most people become better at learning (and doing) science? As much as possible, these items probe students' epistemological views about the efficacy of hard work and good study strategies, *as distinct from* their self-confidence and other beliefs about themselves.

## Conceptual Understanding

Backtracking, Nelson (2006) identified Generation 1 of teaching physics as the traditional approach using textbooks with students as passive learners. Research in the last three decades documented the perennial problem of low student performance in the science, especially in physics. In this, physics education researchers indulge in finding ways to improve learning the course. With Harvard Project Physics, drastic changes in the ideas of teaching style prompted the emergence of Generation 2 that promoted student-centered learning rather than the teacher-centered model. Further development in physics education research distinguished the year 1997 as the rise of the constructivist learning supported by cognitive researched-based materials. In this decade, most of the work in physics education research has been looking at what students know and how they learn (Beichner, 2009). Early tasks searched for probable reasons for the low performance in physics leading to the idea of “misconceptions,” which over time, (McDermott & Redish, 1999) has been renamed as “student difficulties,” or “naïve conceptions.” Research in this field lead to the notion of conceptual understanding via conceptual change popularized by Posner et al. in 1982. This idea considered how ‘*peoples organizing concepts change from one set of concepts to another set, incompatible to the first* (p.211),’ proposed in two types: 1) assimilation – using existing concepts to deal with new phenomena and 2) accommodation – replacing or reorganizing dissatisfying existing concepts with new but intelligible and plausible concepts.

Accordingly, Hewson (1982) expanded the idea of conceptual change by including two major components: 1) *conditions* that need to be met in order for a person to experience conceptual change and 2) *conceptual ecology* which consists of many different kinds of knowledge - the most important of which may be epistemological commitments; metaphysical beliefs about the world; and analogies and metaphors that might serve to structure new information. Learners need to recognize that the new concept is intelligible (knowing what it means), plausible (believing it to be true), and fruitful (finding it useful).

In this theme, investigations have been classified as: 1) identification and analysis of student difficulties (Aguirre, 1988; Goldberg & Anderson, 1989; McDermott, Rosenquist & van Zee, 1987; Peters, 1981; Trowbridge & McDermott, 1980, 1981); 2) development and assessment of instructional strategies (Halloun & Hestenes, 1985; Hestenes, Wells & Swackhamer, 1992); and 3) development and validation of broad assessment instruments (Huffman & Heller, 1995). These conceptual tests are useful in their own right, yet follow-up articles extend their analysis as these assessment instruments could not basically unveil areas of student cognition when they start to modify their concepts or ideas. Some researchers have focused on other areas of cognition to aid conceptual tests determine how learning occurs in students and initiated a type of physics education research categorized as epistemologies (Brown & Hammer, 2008; Dykstra, Boyle, & Monarch, 1992; Posner, Strike, Hewson, & Gertzog, 1982) where they noted that students’ ideas are modified as they learn.

## THE STUDY

Analytical design investigated how culture-based, particularly traditional or local-game-based learning of physics concepts affects the conceptual change and epistemological beliefs of pre-service undergraduate physics students in the Philippines. The process emphasized the analysis of the effect of traditional/indigenous-game-based learning materials in developing conceptual understanding and epistemic beliefs of pre-service undergraduate physics students.

### Participants

The study involved students from a pre-service physics class in the undergraduate level of the Philippines' National Center for Teacher Education. The researcher purposively and conveniently chose these participants as they were the only pre-service physics class enrolled in Mechanics courses in the school year 2014-2015. Participants in this class took the grant offered them by the Department of Science and Technology-Science Education Institute (DOST-SEI) as full national scholar with all the financial and statutory privileges of a grantee. Screening for grantees is done nationwide where a set of criteria with passing mark in a standard examination determined the inclusion of students as national scholars.

Twenty eight undergraduate physics students comprise the participants of this study, eleven (39%) among them are males and 17 (61%) females. These students coming from a diverse cultural populace, were selected, based on aforementioned national screening.

### Instruments

#### *Epistemological Beliefs Assessment for Physical Sciences (EBAPS)*

EBAPS is a 30-item, forced-choice instrument designed to analyze students' epistemologies, their views about the nature of knowledge and learning in the physical sciences developed by Elby, Frederiksen, Schwarz, and White (1999). This instrument targets assessing the belief systems of high school and college students taking introductory physics, chemistry or physical science algebra-based courses and has been widely used by researchers (Morales, 2014) with an interpreted good reliability ( $\alpha = .74$ ) for classroom purposes in the Philippine setting. EBAPS probes students' views along five non-orthogonal dimensions: structure of scientific knowledge, nature of knowing and learning, real-life applicability, evolving knowledge, source of ability to learn.

#### *Force Concept Inventory (FCI)*

FCI is a multiple-choice test that assesses students' understanding of the Newtonian concept of force developed by Hestenes, Wells, and Swackhamer (1992). Each item allows the student to choose between the correct concept and alternative concepts provided as choices. The instrument has 30 questions covering six areas of understanding: kinematics, Newton's

First, Second, and Third Laws, the superposition principle, and types of forces (such as gravitation, friction). With a good reliability ( $\alpha = .71$ ) for classroom use.

### *Laro-ng-Lahi-based physics activities*

These are Physics activities in activity pack designed in harmony with the identified frequently used, played, liked, and enjoyed traditional Filipino games. Standard rules provided by physical education teachers and physics concept-connections of the games confirmed by physics professors distinctly characterize the set of traditional game-influenced activities designed for the activity pack. Content-valid as rated by Physics and Physical education experts and reliable ( $\alpha = .9$ ) which can be excellently used for class purposes.

### **Data Collection**

Data collection process involved three major phases: preliminary stage, integration of culture-game-based learning scheme, and post implementation stage. The aforementioned instruments served as the main sources of data. Additionally, to provide in depth interpretation of the data, conduct of qualitative procedures such as observations and interviews derived important qualitative details related to the effect of culture on epistemological beliefs and conceptual understanding of the students.

#### *Preliminary*

Initial survey gathered the participants' profile inclusive of their age, origin or cultural background, and scholastic standing. FCI and EBAPS deduced both their concepts in mechanics and epistemological beliefs respectively before the implementation stage. The researcher administered the FCI in two-tier scheme, where she asked students to explain their chosen answer in an unstructured format. The students' answers in the unstructured format served as qualitative data for concept attainment prior to implementation and were matched with the taxonomy of misconceptions provided by the FCI assessment package.

#### *Implementation (culture-traditional game-based physics)*

The integration of culture-traditional-game-based physics activities lasted for a semester, about five months in the participants' mechanics course that included concepts of force and motion, energy-work theory, and rotational motion. The researcher implemented the *Laro-ng-Lahi*-based physics activities (Carmen et al., 2015) in the majority of topics covered in Mechanics. Sample of activity sheets in the *Laro-ng-Lahi* activity package are shown in **Figures 1** and **2**.

Some traditional games were a bit modified to include some measurement procedures for quantitative data analysis for students' data collection process. The other activities in the *Laro-ng-Lahi* pack concentrated on the conceptual development of the physics principles. The majority of the traditional games used local and indigenous materials as the main sets of



Lets play...

# Dampa

"The game of hand and rubber band"

<p><b>Game Challenge</b></p> <ul style="list-style-type: none"> <li>Differentiate distance from displacement</li> </ul>	<p><b>Game Mechanics</b></p> <ul style="list-style-type: none"> <li>Pairs will choose their <i>goma</i>'s initial point and mark it.</li> <li>Members of the pair will <i>dampa</i> their <i>goma</i> alternately, 3 turns for each member.</li> <li>Mark all the landing points of the <i>goma</i>, preferably at the center.</li> <li>After all the turns, connect each point to succeeding point. Starting from the line which connects initial point and first landing point, the lines will be lines 1-6 consecutively.</li> <li>Measure the length of each line (lines 1-6).</li> <li>Connect the final point and the initial point with a straight line and measure its length.</li> <li>Record all measurements on the given table.</li> <li>The pair with the longest final straight line wins.</li> <li>In case of ties, tied pairs will have another turn.</li> </ul>
<p><b>Game Instruments</b></p> <ul style="list-style-type: none"> <li>chalk, 1 <i>goma</i> (rubber band), meter stick or ruler</li> </ul>	
<p><b>Game Area</b></p> <ul style="list-style-type: none"> <li>Wide area</li> <li>Free from any obstruction</li> <li>Smooth flooring</li> </ul>	
<p><b>Game Background</b></p> <ul style="list-style-type: none"> <li>Played in pair</li> <li>Free competition (pair with best result wins)</li> <li>1 <i>goma</i> per pair</li> <li>6 turns per pair</li> <li>Point- position of the <i>goma</i>, place where the <i>goma</i> rests, landed area</li> </ul>	

Activity I: Distance and Displacement & Dampa—Activity Proper

Physics and Laro ng Lahi Hand in Hand ①

## Distance and Displacement & Dampa

### Physics Concept

### Game Trivia

- Scalar quantities are quantities that can be completely specified by **magnitude** and has no direction.
- Vector quantities are quantities which has both **magnitude and direction**
- Distance is the total length of space travelled by an object.
- Displacement is the length of the straight line from initial position of an object to its final position with given direction.
- Distance is a scalar quantity while displacement is a vector quantity.

- Dampa is played with *goma* (rubber band)- *goma* often come with different *colors*.
- Rubber bands are also called *lastiko* in the vernacular.
- Dampa*- is the action of tapping the ground where compressed air is formed and released causing the *goma* to move.
- There are different hand stances that can be used in playing. You can use any stance.
- Arm strength is developed in players.

Activity I: Distance and Displacement & Dampa—Supplementary Texts


Figure 1. Sample Laro-ng-Lahi-based Physics Activity Guide

Lets play...

# Dampa

"The game of hand and rubber band"

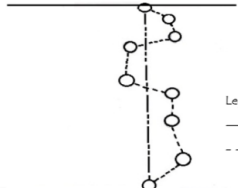
**Game Illustrations**



Tips:

- Make sure that the air can only exit in a hole near the fingertips where the *goma* is adjacent, close all the other holes.
- Narrow the hole where the air will exit.

Figure 1. Hand stance



Legend:

- is line 1
- is line 2

Figure 2. Example output for the activity

Activity I: Distance and Displacement & Dampa—Activity Proper

Lets talk about...

## Distance and Displacement

"Travel more, walk less"

### Game Figures

Table 1: Length of Lines

Line	Length (cm)
1	
2	
3	
4	
5	
6	
Total length travelled:	

Length of the straight line connecting the initial and final point (cm): \_\_\_\_\_

### Game Recap

1. How would the line that connects all the points and the final straight line be compared?

\_\_\_\_\_

\_\_\_\_\_

2. Which line represents distance travelled by the *goma*? displacement of the *goma*?

\_\_\_\_\_

\_\_\_\_\_

Activity I: Distance and Displacement & Dampa—Data Sheet

Figure 2. Sample game illustration and student work sheet

materials while standard materials for measurement deduced several quantitative data for student analysis.



**Figure 3.** Physics students in action (Dampa and Sipa)

The sessions are conducted six hours in a week with three-hour lecture and three-hour laboratory contact sessions. The whole study provided about 108 contact hours with the students using the culture-game-based integration scheme. Session preliminaries include engaging the students to the topics through higher-order thinking skills questions. Then, they are presented with the objectives of the lessons/topics and the corresponding *Laro-ng-Lahi*-based activities. Students conducted these activities either in-door or out-door depending on the activity area requirement (see sample on **Figure 3**). Participants wrote all their data on the provided worksheets, and analyzed their gathered data using the provided guide questions in the same worksheets. Post-activity discussions included facilitating the post-activity questions, probing mechanisms to extract learning and observing in relation to the topic as influenced by the traditional Filipino game-context activities.

Structured laboratory activities supplemented these *Laro-ng-Lahi*-based mechanics activities. Also, the participants logged their insights and reflections on the conduct of the sessions especially highlighting their experiences on the integration of traditional Filipino games in learning physics concepts. Interviews with selected participants clarified and verified their reflections, comments and insights on the sessions. Questions posted in the interview focused on their experiences in the conduct of the Filipino games-based physics activities; their

affective transition; and their cognitive and conceptual change while subjecting them to these activities.

### ***Post Integration***

Post administration of FCI and EBAPS deduced the participants' development in the area of conceptual understanding and epistemological beliefs respectively. The FCI was again administered as a two-tiered test where the researcher asked the participants to write their conceptual explanation for their chosen answers. Analysis of their unstructured explanations provided strong sense of what conceptual development evolved during the course of the integration in comparison to their pre-implementation explanation and mapped with the misconception taxonomy. Analysis of their answers in the worksheets extracted the participants' formative development in conceptual understanding and epistemological beliefs, while observations and interviews detailed other aspects of their conceptual and epistemic development which may not be possibly captured by the instruments.

### **Data Analysis**

Descriptive statistics and comparison of means provided quantitative information on the conceptual and epistemological development of the participants. Students' concept explanation in the worksheets and their 2<sup>nd</sup> tier answers in FCI were mapped with the embedded misconception taxonomy of the instrument (Hestenes, Wells, & Swackhamer, 1992) and their initial 2<sup>nd</sup> tier explanation to check any conceptual changes. Thematic analysis of interviews, journal insights and class observations guided by the misconception taxonomy inferred the formative development of the participants' conceptual understanding and epistemological beliefs.

## **RESULTS AND DISCUSSION**

To restate, the study attempted to explore if culture-game-based (Laro-ng-Lahi) based physics activities can facilitate developing the conceptual understanding and epistemic beliefs of pre-service physics students. Discussion of the results highlights the progress of pre-service students in achieving the correct scientific concepts and the probable development of their naïve beliefs through the integration of traditional Filipino games in the participants' learning aspects.

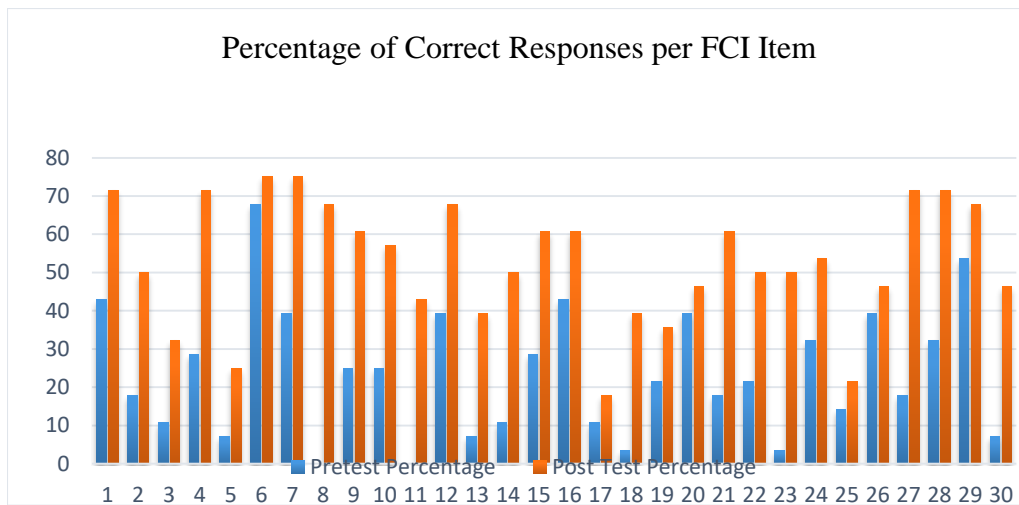
### **Conceptual Understanding Enhancement**

As defined by Chaimala (2004), the notion of conceptual understanding in science education is linked to the idea of Posner et al. (1982) -- "conceptual change," -- which explained how people change their ideas that disagree with their prior knowledge. Conceptual change included two types: 1) assimilation - using existing concepts to deal with the new phenomena and 2) accommodation - replacing or reorganizing central concepts for a more intelligible and plausible concept. **Table 2** provides the comparison of the following: pre-test and post test

**Table 2.** Comparing correct concepts and alternative concepts

Constructs	Mean		SD		p-value
	Pre-Test	Post-Test	Pre-Test	Post-Test	
FCI correct concepts	6.60	14.8	4.7	4.54	.001*
FCI alternative concepts	21.60	12.60	19.7	11.5	.000*

\* significant at .05



**Figure 4.** Percentage of Correct Responses in FCI coded Items

results on FCI; and 2) pre-test and post-test records on the chosen alternative concept results using FCI’s misconception taxonomy.

**Table 2** indicates higher mean and standard deviation (M=14.8, SD = 4.7) for the post – test in the FCI coded correct responses. The computed mean difference of the pre-test and post-test in the FCI coded correct responses is statistically significant ( $p = .001 < .05$ ) in favor of the post-test. This result may mean that increased understanding of the Newtonian concepts in students was facilitated by the culture-game based physics activities which featured the use of traditional Filipino games in teaching Newtonian concepts. Extending the analysis, post-test mean and standard deviation of the FCI coded alternative concepts is lower (M = 12.60, SD = 11.5) compared to the pre-test mean and standard deviation (M = 21.60, SD = 19.7) which suggests that the participants hold significantly fewer alternative concepts after implementing the culture-game-based physics teaching and learning.

Plotting all the FCI items and the correct responses (**Figure 4**) of the participants indicates that the participants performed better in the post test, as shown in the increased percentage of correct responses in all the FCI items.

Large increase can be observed in almost all items except in item nos. 6, 20 and 26 that were focused on the concepts of: 1) no force, 2) acceleration discriminated from velocity, and 3) with no force velocity direction constant for the law of inertia. Mapping the culture-game based physics activities with the following: 1) Newtonian concept inventory (Hestenes, Wells, & Swackhamer, 1992); 2) culture-game based activities; 3) inventory of items; 4) items with increased correct responses; 5) addressed misconceptions from the misconception taxonomy (Hestenes, Wells, & Swackhamer, 1992); and 6) percentage decrease in frequency (**Table 3**) may provide valuable insights into the participants' conceptual change and understanding.

The summary presented in **Table 3** identified the specific traditional-game influenced physics activities that provided venues for students to change their previously held alternative concepts to the correct scientific ideas. As mapped out, much of the conceptual change experiences of the participants were on topics related to the laws of motion and kinds of forces. On the other hand, very few traces of assimilation or accommodation are observed in topics:

**Table 3.** Summary of topics, items, correct responses and addressed misconceptions

Taxonomy of Topics	Culture-Game based physics activity	Inventory of Item	Items with increased correct responses	Addressed misconceptions based on the taxonomy (percentage decrease)
Kinematics	<i>Dampa</i> (rubber band game)	19	19	Position-Velocity undiscriminated (17.2)
• Velocity discriminated from position	<i>Tumbang preso</i> (dock on a rock)	20	20	
• Acceleration discriminated from velocity		14, 21	14, 21	
• Constant acceleration entails		22	22	
○ Parabolic orbit		9	9	
○ Changing speed				
• Vector addition of velocities				
First Law	<i>Tumbang Preso</i> (dock on a rock)	7, 8, 6	7, 8, 6	Impetus supplied by "hit" (17.4)
• With no force		23	23	Impetus dissipation (21)
○ Velocity direction constant	<i>Sipa</i>	10, 24	10, 24	Circular impetus (21.7)
○ Speed constant	<i>Dampa</i> (rubber band game)	17, 25	17, 25	Motion implies active force (100)
• With cancelling forces				
Second Law	<i>Luksong baka</i> (leap frog)	8, 9	8, 9	No motion implied no force (100)
• Impulsive force				Velocity proportional to applied force (36.8)
• Constant force implies constant acceleration	<i>Shato</i> (gillidanda)	21, 22	21, 22	Acceleration implied increasing force (40)
Third Law				Force causes acceleration to terminal velocity (30.4)
• For impulsive forces		4, 28	4, 28	Greater mass implied greater force (36.9)
• For continuous forces		15, 16	15, 16	

Source: Hestenes, Wells, & Swackhamer. (1992). A taxonomy of misconceptions. *The Physics Teacher*, 30, 141-158

**Table 3.** Summary of topics, items, correct responses and addressed misconceptions (*continued*)

Taxonomy of Topics	Culture-Game based physics activity	Inventory of Item	Items with increased correct responses	Addressed misconceptions based on the taxonomy (percentage decrease)
Superposition principle	<i>Patintero</i>			Most active agent produces greatest force (34.3)
• Vector sum	(block the enemy game)	5	5	
• Cancelling forces	<i>Hilaang lubid</i> (tug-of-war)	11, 17, 25	11, 17, 25	Force compromise determines motion (13.2)
Kinds of forces	<i>Sipa</i>			
• Solid contact	<i>Dampa</i>			Last force to act determines motion
○ Passive	(rubber band game)	11, 29	11, 29	Centrifugal Force (87.8)
○ Impulsive		18	18	Mass makes things stop (100)
○ Friction opposes motion	<i>Luksong baka</i> (leap frog)	27	27	Motion when force overcomes resistance (33.3)
• Fluid contact	<i>Shato</i>	30	30	Motion when force overcomes resistance (13.2)
○ Air resistance	(gillidanda)	29	29	Heavier objects fall faster (40.5)
○ Buoyant force (air pressure)		13, 11, 29, 3, 17, 30	13, 11, 29, 3, 17, 30	Gravity increases as objects fall (40)
• Gravitation		1, 12	1, 12	Gravity acts after impetus wears down (61)
○ Acceleration independent of weight		12, 14	12, 14	
○ Parabolic trajectory				

Source: Hestenes, Wells, & Swackhamer. (1992). *A taxonomy of misconceptions. The Physics Teacher*, 30, 141-158

1) kinematics and 2) superposition principles. This result might be due to the fact that most culture-game-based physics activities were intentionally designed to influence Newtonian physics topics other than kinematics and superposition principles. Incidentally, these Newtonian topics believed to be directly influenced by the culture-game based physics activities present high increase in the percentage of correct responses and large decrease in the alternative conceptions suggesting that these successes may contribute to the development of the participants' notion of conceptual understanding.

In an interview with several students and with their journal logs expressing their reflections on the activities, they expressed positive views on using traditional/indigenous games in teaching Newtonian concepts. They were also asked as part of their reflection how will they teach the same Newtonian concepts when they eventually become teachers. Most of them answered that using traditional Filipino games made them feel a concomitant sense of nationalism while engaged in a scientific field and that they were also willing to try the activities and framework to their future students when they become physics teachers. Below are sample transcriptions of their:

*"Nice game, helpful in cultivating young minds to engage in physics."*

*"This game deserves applause for it enshrines nationalism in Physics classes.*

*"However, it is recommended that the teachers should be skillful in teaching and/or using Dampa (rubber band game) game so that the students will be encouraged and appreciate the game thereof. It is fun to do but at the same time, it may also result to some difficulties especially to those who never experienced the game in their childhood."*

*Dampa (rubber band game) is one of the best games to describe and show the relationship of distance and displacement. Nice game! Pure Filipino."*

The pre-service physics students' success in conceptual change attaining the notion of conceptual understanding may also be attributed to the part of the culture-game based physics activity and journal log entries where they were asked to suggest ways on improving the activities or changing the configurations of the activities when they use them in teaching physics (Newtonian concepts). In this activity and journal log exercise, participants seem to combine the effort of completely understanding the concept and matching it with an ample knowledge of the traditional game for them to come up with ways of improving these activities which will fit how they intend to teach the course later in their teaching career. Paul (2011) identified this teaching and learning process as being resurrected by scientists who believed in the wisdom of the Roman philosopher Seneca, "While we teach, we learn." Paul reiterated his earlier findings that students enlisted to tutor others work harder to understand the material, recall it more accurately and apply it more effectively dubbed as "the protégé effect," where student teachers score higher on tests than pupils who are learning only for their own sake. Some of their suggestions to better implement traditional games in teaching physics when they eventually become teachers were:

*"It would be better if the players had different position when performing dampa (rubber band game) so that the goma (rubber band) would have different position."*

*"We suggest that the experiment set up include a sensor, so that the measurement will be more reliable and accurate to use."*

*"It would be better if we considered the number of times the slipper would hit or touch the can as the number of hits rather than the number of times the players could release/throw their slippers. In this way, we could easily compare the inertia of cans with different masses."*

These activities served as antecedent to developing the participants' epistemic beliefs of the pre-service physics students such real-life applicability, source of knowledge and nature of learning. Traditional Filipino games played even in their childhood may yet surface as fitting agent for connecting concepts to real life applications, where these students may extract the knowledge and Newtonian concepts as well as see connections between and among concepts.

**Table 4.** Comparison of epistemic beliefs dimensions before and after implementing culture-game-based physics activities

	<b>Pre-test</b>	<b>Interpretation</b>	<b>Post-Test</b>	<b>Interpretation</b>	<b>p-value</b>
Structure of scientific knowledge	2.14	Poorly sophisticated	2.16	Poorly sophisticated	.635
Nature of learning	2.40	Moderately sophisticated	2.41	Moderately sophisticated	.860
Real Life Applicability	2.65	Moderately sophisticated	2.60	Moderately sophisticated	.234
Evolving Knowledge	2.28	Poorly sophisticated	2.30	Poorly sophisticated	.887
Source of Ability	2.85	Moderately sophisticated	2.90	Moderately sophisticated	.438
OVER ALL	2.39	Moderately sophisticated	2.40	Moderately sophisticated	.778

\* significant @ .05

### Epistemic Beliefs Development

BonJour (2002) considered epistemology as the branch of philosophy that explores what knowledge is and how people know whether they know something. Accordingly, epistemology addresses questions such as: What is knowledge? How do people know if they really have knowledge? What provides a justification for any knowledge that they have? Furthermore, epistemology, as defined by Phan (2006), is a branch of philosophy concerned with the nature of knowledge and justification of beliefs. These held beliefs about the nature, nature of science and the validation of students' beliefs are described in the five dimensions of beliefs: stability of knowledge, structure of knowledge, source of knowledge, malleability of knowledge, and speed of learning. Elby's (1999) Epistemological Beliefs Assessment for Physical Sciences (EBAPS) provides analysis of students' views along five non-orthogonal dimensions: structure of knowledge, nature of knowing and learning, real-life applicability, evolving knowledge, and source of ability to learn. Consequently, **Table 4** provides the comparison of the epistemic beliefs results from EBAPS administered before and after using the culture-game based physics activities to the participants.

Based on **Table 4**, the pre-test and post-test results indicated poor sophistication in two out of five dimensions: structure of scientific knowledge and evolving knowledge results suggesting that participants considered physics knowledge as bunch of weakly connected pieces without much structure and consisting mainly of facts and formulas. Furthermore, their evolving knowledge dimension suggested that they tended to move towards absolutism where they think that all scientific knowledge is set in stone. These results confirm the initial findings of Morales (2014) that Tagalog learners (the majority of the participants) recognized physical science knowledge (Physics and Chemistry) as isolated and unconstructed bits and pieces of facts. That learning science, particularly physics, was learning bits and pieces of facts set as concrete and fixed.



Three of five dimensions in the pre-test and post-test indicated moderate sophistication: nature of learning, real-life applicability and source of ability. The result on nature of learning suggests that learning science is moving from the context of mainly absorbing information toward constructing one's own understanding by working through the material actively, by relating new material to prior experiences, intuitions, and knowledge, and by reflecting upon and monitoring one's understanding. For real-life applicability rated as moderately sophisticated it suggests that participants may be inclined towards the belief that science concepts apply more generally to real life. Finally, source of ability to learn (moderately sophisticated) suggests that being good in science is a mix of fixed natural ability and the efficacy of hard work and good study strategies. These results conform to the findings of Morales (2014), where she identified the same moderate sophistication in the three aforementioned dimensions suggesting that Tagalog learners (the majority of the participants) viewed learning science as vital in daily life and perceived good performance in science, specifically in physics, as a blend of natural ability and hard work. Overall, the participants' epistemological beliefs were categorized as moderately sophisticated, a rating higher than the identified overall naive beliefs of Tagalog learners found.

Notably, these results indicated no statistically significant difference between the participants' belief ratings in the pre-test and post-test even with the use of culture-gamed (*laro-ng-lahi*) based physics activities. Similarly, Brauer and Wilde (2014) found the same trend in pre-service teachers noting that most new pre-service students do have naïve beliefs that did not change over several semesters (five semesters). Thus, suggesting a long training and stronger emphasis on developing epistemological beliefs. The literatures (Han & Jeong, 2013; Conley, Pintrich, Vekiri, & Harrison, 2004) also suggest that early and continuous development of epistemologies may contribute to improve the students' belief systems. These authors identified the grade school and high school levels as the probable venue for significant beliefs improvement.

### **Implications of the Study**

The use of Filipino traditional games integrated in physics activities provided venues for students to accommodate most Newtonian concepts achieving conceptual change leading to a concrete concept understanding of the Newtonian ideas. Such activities may have provided the participants with the necessary conditions that challenged their prior knowledge for them to view the extracted concepts using the traditional Filipino games as intelligible, plausible, and fruitful to be able to accommodate the Newtonian concepts and achieve conceptual change.

A positive significant result in the FCI on conceptual change of the participants leading to the notion of conceptual understanding identified the influence of using and integrating traditional Filipino games in physics activities on this cognitive construct. Although the epistemic beliefs of the pre-service teachers did not significantly change over a semester, promising results may be obtained with sustained development of epistemic beliefs using the

influence of Filipino culture. This probable progress in epistemic beliefs of the pre-service physics students reinforces earlier findings of May and Etkina (2002) that epistemological beliefs highly correlate with conceptual learning gain in introductory physics. With this inference, sophisticated beliefs of pre-service physics students may be developed over the entire teacher training program using culture-influenced training and learning. Chan (2004) found the same idea that epistemological development of students is mediated by culture-specific educational environments and interaction. Results of her study implied that educational environments and academic practices in a culture, regardless of students' gender and field of study seem to influence the development of epistemological beliefs. Thus, with the developed belief systems of pre-service teachers, concrete conception about teaching/learning may also be enhanced which will eventually lead to success in addressing student difficulty in physics in the basic education.

### CONCLUSION

The findings of the study emphasize that the use of the traditional national games (*Laro-ng-Lahi*) in the teaching and learning process of pre-service physics students provided the *conditions* and *conceptual ecology* for them to undergo conceptual change and achieve conceptual understanding. In the case of their epistemological beliefs, although there was a non-statistically significant comparison of pre and post EBAPS implementation, the minute changes in their epistemic beliefs show that these traditional game (*Laro-ng-Lahi*) based physics activities may somehow influenced their epistemic beliefs. Large-scale changes in the students' belief systems are expected to surface if the participants undergo a prolonged and sustained use of culture-based learning process. The aforesaid finding and projection somehow confirm what May and Etkina (2002) found that students with high conceptual gains tend to show better articulated reflections on learning and sophisticated epistemologies than students with lower conceptual gains. But, the development of these epistemic beliefs may happen over time as claimed by Loyens, Rikers and Schmidt (2009), students' conceptions of learning and conceptions of knowledge develop progressively through their educational experiences. Moreover, Bendixen and Rule (2004) called these progressive developments of beliefs about knowledge and knowledge construction (knowing) as present in what they call "developmental stages."

Epistemic development may also be culture influenced – a similar idea found by Chan (2004). Their concept of knowledge source and construction may be dictated by how they normally and usually form schema about things, concepts and ideas that they learn. The real-life applicability dimension may hold a big chunk of success when culture influences pre-services students' learning process. As one culture (traditional Filipino game) exhibits several physics concepts, learners may be able to infer conceptual coherence of scientific ideas consequently leading to the idea of a unified whole making the "structure of scientific knowledge dimension" qualify for a sophisticated status of belief system. Furthermore, this system of learning influenced by culture may be viewed as evidenced-based learning where

teachers and students observe the concepts through the physical *Laro-ng-Lahi*-based activities.

### RECOMMENDATIONS AND RESEARCH IN THE FUTURE

Only one group of pre-service physics students participated in this study, thus, other studies could use the framework to extend the work to all other pre-service science students in the Philippines. Curriculum designers could develop culture-influenced curriculum materials that make use of religious beliefs, practices, and traditions such as celebration of fiesta and the like. They may also incorporate other traditional national games in designing classroom activities. These culture-influenced activities and curricula may be provided in different languages for better results (Morales 2015).

A longitudinal research may be employed for more encompassing results. This process will improve data gathering and analysis as much as explore what particular aspect of culture-influenced learning and teaching of science concepts would eventually develop the epistemic beliefs of pre-service students. Equally, a triangulation of the cognitive, affective and psychomotor constructs of learning may also provide better analysis of culture-influenced learning in the perspective of developing students' belief systems. Learners' involvement in all these domains of learning would be supervised and harmonized with the different stages of their psychological development. In the teaching aspect, series of professional development programs on integration of culture and language in the teaching of science may be operated for the experimental process on the teaching aspect.

The study sought some answers to a prevalent concern on developing the epistemic belief system of pre-service physics teachers from naïve beliefs to sophisticated ones leading to improving beliefs on teaching and teaching practices. The use of learner's local culture and tradition through *Laro-ng-Lahi* based physics activities considerably plotted the process and framework of how to learners transfer their natural learning patterns to attain conceptual change and eventually develop their epistemic beliefs. However, some limitations were identified along the course of the investigation. Integration of such game-based physics activities may be enhanced by adopting the suggestion of participants and incorporating them in the improved activities. Since the new Philippine education system follows a spiral progression of science concepts integrating the four areas: physics, chemistry, earth science and biology in a year level, culture-based activities using traditional games may be anchored on other science areas to accommodate concept progression and interrelatedness promoting interdisciplinary approach using the Filipino traditional games and providing venue for developing several constructs of epistemic belief systems such as structure of scientific knowledge and real-life applicability. Replicated studies may include language aspect along with other forms data collection processes.

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