Incorporating Indigenous *Bukre* Game Into Mathematics Lessons: A Teaching Experiment

Peter Akayuure
Department of Mathematics Education, University of Education, Winneba, Box 25, Ghana

Clement Ayarebilla Ali
Department of Basic Education, University of Education, Winneba, Box 25, Ghana

ABSTRACT

One major drawback to the curriculum demand for the use of indigenous games in mathematics classrooms is the inability of most teachers to identify the mathematics in these games and consequently incorporate them when teaching specific mathematics content. The primary purpose of the study is therefore to analyze and show how the indigenous *bukre* game could be incorporated into the teaching and learning of probability concepts in junior high school mathematics. Forty-five pupils from Vea Junior High School and a 79-year old knowledgeable man were purposively engaged in *bukre* game and data were gathered by participant observations and interviews. A comparative analysis uncover that, similar to the classical experiment of tossing a coin, a variety of probability concepts surrounds *bukre* game. It is also observed that the game can promote pupils' native conception of probability, intrinsic motivation, friendly classroom dialog and interactions. Implications were discussed within the framework of projecting the use of indigenous games and knowledge systems in teaching and learning mathematics.

Keywords: *Bukre* game in Ghana; Constructivist framework; Indigenous game; Mathematics; Probability

1. INTRODUCTION

It is widely recognized in literature that meaningful teaching and learning cannot be disconnected from the social interactions situated in learners' cultural frameworks (Toulouse, 2013; Sparrow & Hurst, 2012; Chinn, 2007). In particular, Toulouse (2013) asserts that the educational success of indigenous students requires that teachers deconstruct those shadows of colonial effects that permeate the indigenous teachers' practices. It can therefore be argued that a good teacher is one who is culturally sensitive to the environment within which s/he operates (Muzangwa & Chindanya, 2014; Huylebrouck, 2006).

The context in which mathematics is utilized in different cultures has been severally acknowledged in research and curriculum reforms (Adebar & Swift, 2014; Nabie & Akayuure, 2014; Rosa & Orey, 2013; Chikodzi & Nyota, 2010; Nkopodi & Mosimege, 2009). All these authors acknowledge the importance of adopting culturally responsive pedagogies to the teaching of mathematics and other disciplines. An analysis of the 1987 and 2004 curriculum reforms in Ghana reveal an emphasis towards the integration of the indigenous knowledge systems into the formal education system (Nabie, 2015; Nabie & Akayuure, 2014). The introduction of indigenous or cultural games in the 1987 reform was deliberately intended to help transform and contextualize mathematics teaching as well as locate mathematics instruction in the social domain of the Ghanaian child (Nabie, 2015). To facilitate the reform demand, the Ghana Education Service has since promoted indigenous games through competitions in schools and supported international participation in related competitions. However, till date, these reform intentions remain a challenge for teachers who are responsible for incorporating indigenous games into the mathematics classrooms.

Research finding reveals that although many teachers may be aware of advantages of using indigenous games, "few experienced them at the point where their pedagogical skills are developed" for classroom practices (Nabie, 2015, p. 219). Observations points to teacher knowledge base, and the low presence of mathematics books, teaching guides and resources that portray the Ghanaian cultural games. Also, teaching experiments aimed at mathematical analysis and use of indigenous games in classrooms remain limited in literature. In this study, we present a mathematical analysis of an indigenous *bukre* game of the Frafras ethnic group to drum home the Ghanaian context to learning probability concepts in mathematics. The analysis could generate more investigation into the mathematics and pedagogical value of indigenous Ghanaian games in classrooms. The ultimate goal should be to expedite reform drive towards implementing pedagogies that will demystify the learning of mathematics, reduce mathematics phobia and make mathematics culturally relevant.

2. LITERATURE REVIEW

2.1 MATHEMATIZATION OF INDIGENOUS GAMES

According to Nkopodi and Mosimege **(**2009)**,** game activities include children's plays, puzzles, board games, dice games, card games, word games and team sports. In Ghana, indigenous game activities such as *Oware* and *Dame* (see Owusu-Mensah & Baffour, 2015), *Daha*, *Bukre* and *Baabaa* (see Nabie & Akayuure, 2014) have also been cited but there are still many of them which remain undocumented. These game activities have well-defined goals and rules which are usually agreed upon by members. Indigenous games also have local origin and are associated with the mores of cultural groups.

The majority of these games are usually intended for recreation, competition, fun and pastime plays. Characteristically however, game plays require mathematical skill, strategy and chance. As a result, the mathematization of games is being acknowledged by ethno-mathematics educators across communities. Rosa and Orey (2013) describe mathematization as the process in which members from distinct cultural groups develop different mathematical tools to aid them in organizing, analyzing, predicting, modelling and solving problems in the context of their own real life affairs. They further explain that most ethnic groups have different ways of connecting mathematics to their own cultural, social, political, and economic activities. Dewah and Van Wyk (2014) claim that indigenous games, as cultural commodities, are embedded with several mathematics concepts, principles and processes that are associated with some indigenous knowledge systems. Therefore, indigenous games could serve as tools in the formal school system for developing children's mathematical abilities for scientific and social advancements.

2.2 INDIGENOUS GAMES IN MATHEMATICS CLASSROOM

Some studies provide indication about the significance of indigenous games in learning school mathematics. Chikodzi and Nyota (2010) claim that indigenous games stimulate children's mathematical imagination and logical thinking. Nabie (2015); Owusu-Mensah and Baffour (2015); and Mccoy, Buckner and Munley (2007) agree that the use of cultural contexts in teaching makes mathematics relevant, accessible, pleasurable, memorable and meaningful for all students. In their view, the use of indigenous cultural games in mathematics classroom provides an opportunity for pupils to relate their experiences outside the classroom to mathematical processes in the classroom. This tends to create awareness between mathematics and the real life and also lessens the phobia towards the learning of mathematics. The use of indigenous games in the classroom builds a relationship between culturally specific activities and classroom activities (Ministry of Education, Science and Sports, 2007).

Other studies (Adebar & Swift, 2014; Rosa & Orey, 2013; Nkopodi & Mosimege 2009; Chinn, 2007) explore how ethno-mathematics may be implemented in the mathematics classroom and ways of dealing with pedagogical challenges. According to Nkopodi and Mosimege (2009) for example, ethno-mathematics has contributed to deeper understanding of how various cultures can be interpreted in the mathematics classroom.

Nabie and Akayuure (2014) argue that the social context within which games are played facilitates meaningful learning. The interactions in games encourage students to argue, listen and make sense of viewpoints of others and in the process develop understanding of concepts better than their original ideas. Indigenous games also provide a natural environment which helps children to overcome ontogenetic, didactical and epistemological obstacles in learning mathematics (Vankus, 2005).

Aside indigenous games being used as recreational or pastime activities, they perform didactic role in mathematics classroom. When students' engage in game play, a variety of mathematical activities are generated within which mathematical concepts, skills and vocabulary assimilated. For instance, indigenous games like *pada* and *nhodo* in Zimbabwe, *cowry* in Cote d'Ivore and *mu torero* in New Zealand, can be used to help learners form new mathematical concepts or practise and consolidate mathematical skills (Dewah & Van Wyk, 2015). Moreover, indigenous games can be used to as tools to:

- learn the vocabulary of mathematics
- develop mental mathematics and mathematical skills
- generate mathematical activity at different levels
- stimulate investigations and problem solving
- patterns discovery, logics, etc.

(Nabie & Akayuure, 2014; Rosa & Orey, 2013; Sparrow & Hurst, 2012)

3. PROBLEM STATEMENT AND PURPOSE OF THE STUDY

Literature review points out that when the cultural treasure that pupils bring from home is relegated to the margins of the classrooms, mathematics learning becomes less productive to those pupils (Chilisa, 2012; Sparrow & Hurst, 2012). Pupils' cultural treasure include their indigenous play games. This implies that in order to make mathematics learning more productive, there is the need for teachers to integrate indigenous games into their teaching practices. Recent studies (Nabie, 2015; Nkopodi & Mosimege**,** 2009) however reveal that many teachers are pedagogically limited in the use of indigenous games in classroom. Nabie (2015) reports that very few mathematics teachers could translate their experience with indigenous games into their teaching practice. More so, most mathematics teachers appear to be unaware of the mathematical contents of indigenous games and how to localize indigenous games in mathematics lessons. Currently, literature on the mathematics of indigenous games in Ghana (e.g. *Oware, Dame, Bukre and Daha* games) and how to use these games to teach specific mathematics concepts is quite limited. Therefore, an investigation into the mathematics concepts embedded in indigenous game of *bukre* through a teaching experiment is justified. *Bukre* is a prediction game played widely by children of the mole-Dagbamba and other indigenous groups in Ghana. We consider *bukre* game as having huge potentials of being used in classroom to demystify the concept of probability in mathematics, hence the need to ascertain this.

The primary purpose of the study is therefore to analyze the indigenous *bukre* game in relation to the teaching and learning of probability concepts in junior high school mathematics. The secondary purpose is to observe pupils' learning involvements when using *bukre* game in the classroom setting.

4. THEORETICAL FRAMEWORK

4.1 THE THEORY OF GAME AND PROBABILITY

As a social activity, most game plays rely practically on strategy, randomness and chance (Rosa & Orey, 2013) which historically provide basis for theorizing probability. This explains why games were used by ancient mathematicians and mathematics educators to develop probability theory and to teach probability concepts. From the era of Pascal and Fermat, who wanted to answer Chevalier de Mere's question on fair distribution of the stakes of an interrupted gambling game, up till date, the theory of game has been used to illustrate probability. It is argued that any indigenous game which involves the concept of chance is a potential resource for learning probability concepts. For instance, Bagni, D'Argenzio and Luchini (1999) establish that the use of ancient Italian *Zara* game combined with activity linked to everyday life is an effective way to teach probability at the high school. Some authors however express caution about the use of games for learning probability. Burges (1999) highlights the tendency of students to either assume passive roles or become more familiar and skilful in the strategies and chances of winning the game. Also, fewer number of game trials by students may produce less likely outcomes which may conflict with the theoretical basis of probability. Some students may also focus on the game rather than the concepts, if the concepts and the game components are not well incorporated (Bagni, D'Argenzio & Luchini, 1999). Games must therefore be used in classrooms with care.

4.2 SOCIAL CONSTRUCTIVIST THEORY OF LEARNING THROUGH GAMES

The study is framed within the social constructivist theory which states that reality is socially constructed through human activity as in indigenous game activity (Owusu-Mensah & Baffour, 2015). The advocates of this theory (Piaget, Vygotsky and Bruner) say knowledge is derived from interactions between people and their environment (Ernest, 1994). In social constructivism, both the learning (e.g. probability concepts) and the social contexts (e.g. *bukre* game) are central to learners' creation, discovery and attainment of the desire knowledge. This theory encourages what Gattegno describes as subordination of teaching to learning where the teacher acts as a guide and not the sage on the stage, spoon feeding learners with knowledge (Owusu-Mensah & Oppong, 2015). On the other hand, instead of simply reproducing what the teacher or textbook presents, the learners are engaged to construct understanding in their own minds. Moloi (2014) admits that "no matter how lucidly and patiently teachers explain the subject-matter to learners, the truth is that teachers cannot understand for their learners" (p. 587). Consequently, we believe that researchers can construct much more meaning from data they gather when they are fully involved with subjects in the data collection process.

Thus, in relation to this framework, the study is set in two folds: (1) to give us the opportunity to engage ourselves with the *bukre* game and in the process make our own sense of the mathematics embedded in *bukre*, and (2) to engage pupils in a meaningful way that will allow them to form their own conception of probability through *bukre* game. Sparrow and Hurst (2012) observe that learners understand what they learn well when teachers design and build learning situations upon the experiences learners bring to the classroom. Vygotsky highlights the role of game activities in children's socialisation (Vankus, 2005). Owusu-Mensah and Baffour (2015) maintain that game play can help learners achieve the mathematical connections to life situations if teachers can link them to the mathematics in the classroom. As learning is achieved by doing, game play can be useful platform for better construction of mathematical knowledge (Vankus, 2005). In line with the constructivist principles, we seek to understand how indigenous *bukre* game can promote socio-cultural context learning of probability concepts.

5. METHODS

This qualitative study employs analytic and interpretive research design to, firstly, analyze and show various probability concepts involved in *bukre* game and secondly, gain in-depth understanding of the significance of localizing probability concepts through *bukre* game activities. To achieve these, teaching experiments were purposively organised to engage local pupils in bukre activities. A teaching experiment refers to pedagogical research procedure where the learning processes (not learning outcomes) are observed in order to determine how instruction can greatly influence such learning processes (Nkopodi & Mosimege, 2009). In this study, two teaching experiments were applied to enable us introduce *bukre* game to pupils and in the process observe, document and analyse the game process, probability concepts and learners' involvement within the social constructivist context. Only probability concepts ascribed in junior high school mathematics syllabus were highlighted during the teaching experiment. Summary of the steps employed include:

– Stating the objective and Introducing the game to pupils
– Discussing the game, setting rules and grouping pupils in pairs
– Constructing the game environment
– Playing the game and recording outcomes
– Ending the game and reporting outcomes
– Locating concepts and applying the processes and outcomes of the game to probability

5.1 PARTICIPANTS

Vea Junior School (JHS 2 A and B) in the Bongo district of the Upper East Region of Ghana was the study site. The study site was purposively selected because the school authority, the pupils and their teachers consented and were willing to participate in the study. The researchers, who are mathematics educators themselves, were also familiar with the locality, the play and the language of *bukre* game. Thus, it afforded us the opportunity to analyse the game in relation to the pupils' indigenous mathematics knowledge and social domain. In all, 30 male and 15 female pupils within the ages of 13 and 18 contributed with their mathematics teacher teaming with us in teaching experiments.

A 79-year old indigenous man considered as knowledgeable members from Vea voluntarily narrated the history and aim of *bukre* to us and later played the game repeatedly with us. This was recorded to aid us in performing analysis of probability concepts embedded in *bukre* game and to plan a teaching experiment.

5.2 PARTICIPANT OBSERVATION AND INTERVIEWS

The participant observations allowed us to partake in the musical and social aspects of *bukre* like singing the local query song and clarifying the rules and roles expected of participants. Pupils' classroom behaviour and role assignments were noted during the teaching experiment. Also, random sample of 3 female and 3 male pupils from the class were interviewed after class period. The essence of the interview was to find out how participants' think and feel about *bukre* in their understanding of probability. The classroom interactions and responses were video recorded, categorized and coded into common themes for interpretation.

5.3 MATHEMATICAL ANALYSIS

Mathematical analysis entails the identification of mathematical concepts, principles and processes of any game. In this study, the mathematical analysis involved the isolation of aspects of *bukre* game which depict probability concepts. This was done with reference to the classical probability experiments such as tossing of coin, commonly found in textbooks and used in classrooms. Mosimege (2012) cautions that researchers interested in mathematical analysis of indigenous games should not rely solely on their personal mathematical knowledge alone but must also authenticate the correctness of their thoughts with other mathematicians and researchers in mathematics education. In view of this, the mathematics teacher whose classes we interacted with and one mathematics education researcher at the University of Education, Winneba watched the videos of *bukre* game and validated the probability concepts we identified. Some few queries and clarifications made by them led us to finally restrict the analysis to only basic probability concepts in junior high school mathematics syllabus with some few advance concepts. Also, the classroom interactions observed were described and discussed based on our understanding of the tenets of learning in social context rather than as measurable outcomes.

6. RESULTS OF ANALYSIS

6.1 MATHEMATICAL ANALYSIS OF THE INDIGENOUS *BUKRE* GAME

6.1.1 DESCRIPTION OF BUKRE GAME

The *bukre* game environment contains 3 or 4 ovals inscribed within each other on the floor, two marbles for travels and one marble for prediction (See Figure 1). A simple *bukre* game comprises of two players but there could be four players. The players usually sit facing each other around the ovals with one marble each at the edge of the outer oval for travels. The first player hides a marble in one of the fists and the second player predicts where the marble was through a query song in the *Gurune* language (see Table 1). If the predictor succeeds in choosing the fist where the marble is, s/he moves his/her marble inside the first oval and gets the chance to also query. Otherwise, the first player moves his/her marble and continues to query. The player whose marble travels into the inner most oval wins the game.

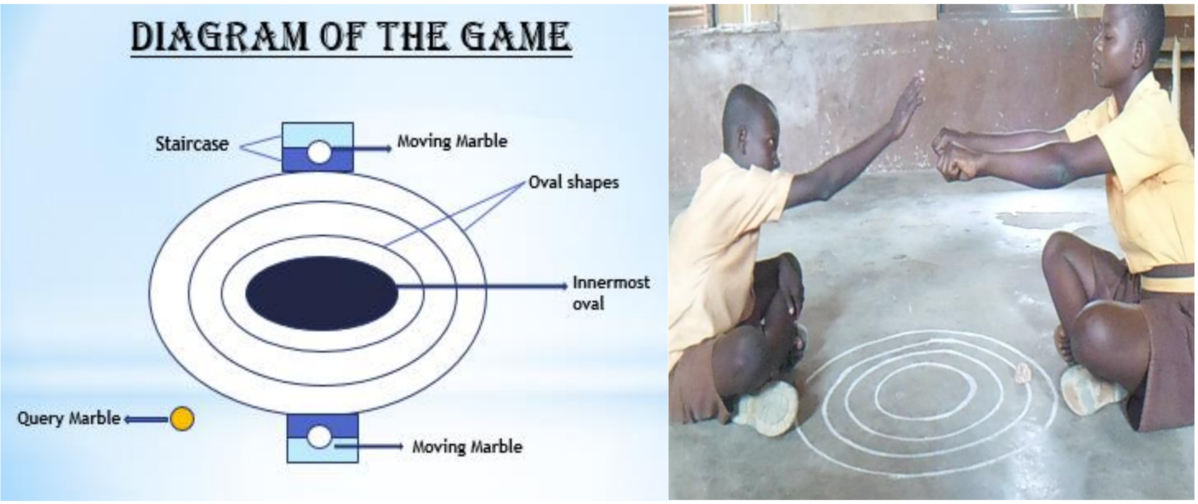

Figure 1: Two pupils of Vea Junior High School playing bukre game in class [July 28, 2015]

Table 1: Query song in Gurune and English and Basic Rules of Bukre Game

Query Song		Basic Rules of *Bukre* Game
Gurune	**English**	
Pak talaki	Let me tell you	1. The marble must be in one of the fist of the player. To ensure this the player must open both palms to show the other player after the query.
Bonga n laki sabere	A donkey gave birth to debts	2. The query song must end/land on the player's choice of the fist with the marble.
Tusa ayi	These are two debts	3. The first player continues to hide the marble until the second player correctly predicts the fist containing the marble.
Gwa gma yi doge	To generate interest	4. The winner is the one who gets his/her moving marble into the innermost circle first.
Sami a tiim	Let me search for debt charm	
Tiim meya bee?	But where is it?	
Dagbo wonna!	It is here!	

According to 79-year old knowledgeable member of Vea, *bukre* was historically used by mystics/soothsayers in royal palaces to foretell where enemies' hide their charms/armlets and to neutralize them before attacking them in the event of war. As time passed on, it became children's play game aimed at deciding the one who can best predict at random. Players are free to decide how many rounds to play or whether only one player should query throughout in each round. Our observation and analysis reveal the following probability concepts embedded in *bukre* game.

6.1.2 RANDOMNESS AND CHANCE

We began the analysis by examining the *randomness and chance* elements of *bukre* as basis for theorizing probability. In playing *bukre*, querying the fist where the marble is hidden is an arbitrary or a random process and the outcomes are only a likelihood of two distinguishable outcomes. The rules of *bukre* are such that players must show fairness with no biases or else loses his/her turn to play. For example, the marble must be in one of the fists, so player 1 must open both hands to show to the opponent (player 2). Also, the fist where the query song ends on is where player 2 chooses. To predict correctly, the player must strategize her/his queries. Player 2 has chance to play only if s/he predicts correctly. The game is characterised by random choices and possibilities similar to classical probability experiments.

6.1.3 EQUALLY LIKELY OUTCOMES AND SAMPLE SPACE

There are basically two possibilities in a query which makes *bukre* comparable to the classical probability experiment of tossing a coin. Similar to tossing a coin, the *equally likely outcomes* include a *Buke* and a *Zanga*. If we let B stand for success (*Buke)* and Z for failure (*Zanga*), then the *sample space* (S) of the *bukre* experiment is S = {B, Z}. If the 1^{st} player succeeds the 1^{st} query, s/he may either succeed again (BB) or fail (BZ) in the 2^{nd} query. On the other hand, if the 2^{nd} player fails in the 1^{st} query, s/he may succeed (ZB) or fail again (ZZ) in the 2^{nd} query. i.e. S = {BB, BZ, ZB, ZZ}. The equally likely outcomes can be shown on probability tree diagram as in Figure 2.

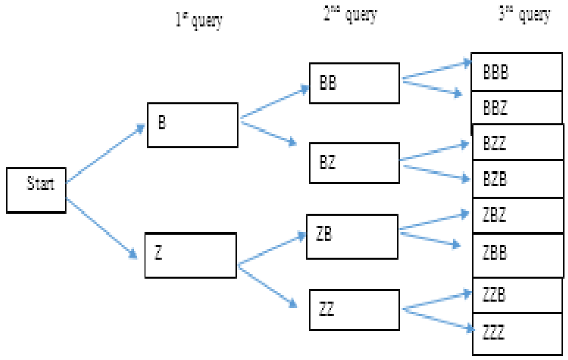

Figure 2: Probability tree diagram of Bukre

Depending on the number of ovals, the permutation of the basic outcomes of *Buke* and *Zanga* can continue to round three and four when the game will end. The sample spaces (set of possible outcomes) for 1st, 2nd and 3rd queries are displayed in the game environment in Figure 3. The number of outcomes in a sample space (S) for n queries of *bukre* game can be obtained using $n(S) = 2^n$.

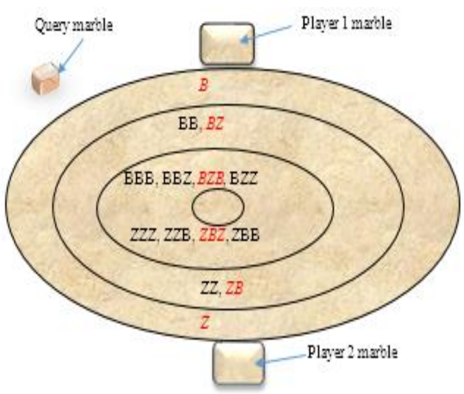

Figure 3: Outcomes of Bukre game for 1st, 2nd, 3rd queries

6.1.4 EVENT OF THE SAMPLE SPACE

An *event* in the sample space of *bukre* game entails the subset of all possibilities of a given number of query. For instance, in a single query, an event of a *Buke* will be E = {B} from S = {B, Z}. In a double query, an event of *Buke* will be E = {BB, BZ, ZB} from S = {BB, BZ, ZB, ZZ}. An event of say two *Zanga* when the *bukre* is queried thrice is E = {ZZB, ZBZ} from S = {BBB, BBZ, BZB, BZZ, ZZB, ZBZ, ZBB, ZZZ}. A single query of *bukre* with two players results in a simple event of say a *Buke* but compound events occur in the 2nd, 3rd, etc. queries. A single query with three players can also result in compound events too. Figure 1 is an illustration of 1st, 2nd and 3rd query outcomes corresponding to movement of the playing marbles from the outer circle towards the inner circle. In Figure 3 outcomes in each oval represent the sample space of that round of query for two players.

6.1.5 EXPERIMENTAL PROBABILITY

The *probability* of an event in the *bukre* game can be illustrated since events can be determined from the various sample spaces of *bukre*. For instance, the probability of a *Buke* in a single query of *bukre* is $P(B) = \frac{n(E)}{n(S)} = \frac{1}{2}$, n(E) = one *buke* from n(S) = two equally likely outcomes. Similarly, the probability of a *Buke* in triple query is $P(B) = \frac{n(E)}{n(S)} = \frac{7}{8}$. (E) = 7 *buke* from n(S) = 8 equally likely outcomes. Table 2 illustrates a comparative analysis of bukre and tossing of coin.

Table 2: Comparison of Bukre and Coin Trials and Outcomes

Concept	Tossing coin	Bukre game
Randomness and Equally likely outcomes	If tossing the coin is just to tell the occurrences then we shall have either Head or Tail (H, T). i.e. there are only two equally likely outcomes. The rules of tossing a coin must be unbiased and so each outcome happens at random.	If bukre is intended to just tell the occurrences then we shall have either Success or Failure (B, Z). i.e. there are only two equally likely outcomes. The rules of bukre must be unbiased and so each outcome happens arbitrarily (random).
Sample space	First trial : {H,T} Second trial: {HH, HT, TH, TT} Third trial: {HHH, HHT, HTH, HTT, THT, THH, TTH, TTT} etc.	First trial: {B,Z} Second trial: {BB, BZ, ZB, ZZ} Third trial: {BBB, BBZ, BZB, BZZ, ZBB, ZZB, ZBZ, ZZZ} etc.
Simple and compound events	Simple events: Tossing a coin once Compound events: Tossing two coins once or tossing one coin twice, etc.	Simple events: Playing bukre once Compound events: Playing bukre twice or playing bukre once with two players, etc.
Chance as probability	The chance of a H in one toss is 1 out of 2. P(H)=$\frac{1}{2}$, i.e. one out of two events	The chance of a success in one game is 1 out of 2. P(B)=$\frac{1}{2}$, i.e. one out of two events
Addition and multiplication laws of probability	P(H or T)= P(H) + P(T). i.e. the probability of a H or T in two tosses . P(H or T)=$\frac{3}{4}+\frac{3}{4}-\frac{1}{2}=1$ P(H and T)= P(H)P(T) i.e. the probability of a H and a T. P(H and T)=$\frac{1}{2}\times\frac{1}{2}=$ P(H) $=\frac{1}{4}$	P(B or Z)= P(B) + P(Z). i.e. the probability of a B or Z in two Bukre . P(B or Z)=$\frac{3}{4}+\frac{3}{4}-\frac{1}{2}=1$ P(B and Z)= P(B)P(Z) i.e. the probability of a B and a Z. P(B and Z)=$\frac{1}{2}\times\frac{1}{2}=$ P(B) $=\frac{1}{4}$
Conditional probability	If H appears in the first toss, what is the probability that H will appear in the second toss?	If B appears in the first bukre game, what is the probability that B will appear in the second bukre?
Binomial probability distribution	In 3 trials, the distribution of H in tossing a coin include: TTT, TTH, THT, HTT, HHT, HTH, THH , HHH 0 1 2 3 X: 0, 1, 2, 3 P(x): $\frac{1}{8}$, $\frac{3}{8}$, $\frac{3}{8}$, $\frac{1}{8}$	In 3 trials, the distribution of B in bukre game include: ZZZ, ZZB, ZBZ, BZZ, BBZ, BZB, ZBB , BBB 0 1 2 3 x: 0, 1, 2, 3 P(x): $\frac{1}{8}$, $\frac{3}{8}$, $\frac{3}{8}$, $\frac{1}{8}$

6.2 ANALYSIS OF OBSERVATIONS OF BUKRE GAME IN CLASSROOM

The following were observations made when *bukre* game was incorporated into the teaching and learning of probability concepts at the school setting. Juxtaposed with our observations are the 'star data' from interviews. The pupils' names referred to are pseudonyms used for the purpose of the analysis.

6.2.1 CLASSROOM INTERACTION AND COLLABORATION

In our observation, we found that *bukre* game created friendly classroom interactions which facilitated the learning process. For instance, during the construction of the game environment, pupils were involved in arguing, explaining and pinpointing to colleagues various strategies, likelihoods, odds and rules of the game. Similar conversations occurred between game partners, between onlookers, and between game partners and onlookers regarding the flouting of rules, singing of the query song and the prediction process. Most interactions were inclined towards those who were winning their games. These interactions are characteristic of indigenous games during children's socializations at homes. Such informal interactions in a stress-free environment as we observed has the potential to deconstruct the formal learning trajectory and allow learners to construct their own understanding. We also observed that the *bukre* game promoted classroom discourse which appear to enhance the development of conceptual understanding. During the identification and application stages of the lesson, pupils were able to refer to the game instances where equally likely outcomes, chances etc. occurred. This kind of communication opportunity builds on pupils' abilities to use appropriate vocabulary to present logical information in both oral and written forms. Since oral and written communications are important aspects of human life, activities such as games which encourage these aspects in classroom setting must be encouraged.

6.2.2 INTRINSIC MOTIVATION

Pupils expressed excitement and keenness in all aspects of the activities from the start of the game through to the application stage up to the closure of the lesson. Every pupils wanted to play the game or refer to an instance in the game to answer or ask questions. No external motives such as rewards for winning the game were used, yet the interest of the pupils kept increasing as the lesson progressed from the play to the application of the game to probability concepts. Atipoka (an interviewee), in response to whether they found the game interesting, said; *it is interesting, I like the way the teacher brought it to classroom. This is the first time I don't know whether that is how the topic is but I am excited. I understand everything the teacher taught us today.* Asibi (another interviewee), also indicated that; … *I enjoyed the class today and I think I understand all the things we learnt today.* Atanga (another interviewee), also noted that; *yes, but I was surprise to see our teacher using the house game to teach us something in math like that. I thought we were just to play before class but it was nice to me.* We particularly observed that even during the discussion stage where the game plays had ended, most pupils were still enthused to play the game and answer questions posed by the teacher.

6.2.3 CONCEPTION OF PROBABILITY

Even though pupils' learning outcomes were not analysed, we noticed that pupils used several informal, intuitive and native ways to describe equally likely outcomes, events and probability. Some alternative conceptions such as *expected outcomes* were used to explain equally likely outcomes. *Gurune* (the local language) words (*buke, luee, waare, di mia,*) were also used by pupils to explain themselves when they had difficulty in describing their conceptual viewpoint in English language. Pupils' conceptual image of probability appear to have been well-built as according to Atanga *it was easy because I don't think I'll forget this topic because if I forget I can think about bukre and just see everything about like probability.* This suggests that *bukre* game can be employed in instructions to contextualize the learning of probability.

7. IMPLICATIONS

Random experiments in the form of play games are often used in classrooms to theorize chance, event and outcome of real world occurrences. This is because they are amendable to classroom situations and provide practical experiences of probability theory and applications. However, as noted by Nabie and Akayuure (2014), the kind of play games used in the formal classrooms and textbooks appear alien to the social domain of the Ghanaian child. This makes the understanding of probability concepts abstract and difficult (Rosa & Orey, 2013). Probability concepts can be made more meaningful to children when indigenous game activities are employed in the classroom (Dewah & Van Wyk, 2015; Chilisa, 2012). The analysis reveals a number of probability concepts such as randomness, equally likely events, chance, laws of probability, conditional and total probability, Bayes theorem and binomial distribution. Pupils also conceived local *Gurune* names for probability concepts like *buke* (success), *luee* (loss), *waare* (draw), *di mia (*win). There are many other mathematical concepts that could be identified in *bukre* game. The concepts of subsets, counting and permutation, binomial expansion in sequence and series are but a few that surround *bukre* game activities. The present mathematical analysis of *bukre* game provides solid grounds for research into the didactic of other indigenous games in Ghana.

Observations during the teaching experiments also reveal that *bukre* game can facilitate classroom interactions and collaboration; promote vocabulary acquisition in mathematics; promote intrinsic motivation; and promote contextual notion of probability

These are useful tenets that pupils require for effective construction of the desire mathematical knowledge (Dewah & Van Wyk, 2015; Chilisa, 2012). In line with social constructivism and the recognition that learning is by doing, it can be implied that incorporating indigenous game contexts and contents into classrooms can ensure that the mathematical knowledge constructed by learners becomes more productive to society (Nkopodi & Mosimege, 2009). The present study supports the observation made by Owusu-Mensah and Baffour (2015) that in this era of African renaissance and technological innovation, the use of pedagogies that integrate indigenous knowledge into classroom activities is the way forward. It is expected that further research on the pedagogical significance of *bukre* game including pupils' learning outcomes in real classroom to support the curriculum reform efforts towards culturally responsive pedagogy. This should help to demystify the learning of mathematics, reduce mathematics phobia and promote indigenous science and technology.

In the study, *bukre* game was analysed to drum home and illustrate the Ghanaian context of learning probability concepts. The study concludes that *bukre* game has huge potentials of demystifying probability concepts when integrated into teachers' classroom activities. To support the mathematics curriculum demand for the use of indigenous games, it is recommended that mathematics teachers should be provided with the knowledge and resources needed to employ indigenous games as tools in their teaching practices.

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