PRIMARY SCHOOL TEACHERS MATHEMATICAL CONCEPTIONS OF CULTURAL GAMES

Michael J. Nabie
Department of Mathematics Education
University of Education, Winneba

ABSTRACT

The study investigated primary school teachers' mathematical conceptions of cultural games in their professional trajectory. In this study, 156 certificated primary school teachers in the Wa Municipality of the Upper West Region of Ghana were surveyed. Using a questionnaire consisting of 29 closed and open-type questions, participants' quantitative and qualitative responses of their reflective interpretations of the mathematics of cultural games were explored. Thematic analysis was applied to participants' qualitative responses whiles descriptive statistical analysis was applied to the quantitative data. The study identified three epistemological perspectives of knowing mathematics from games: by playing, searching for materials, and in constructing the game. The study indicated that different games can embody the same mathematics (multiple games-one concept relationship) and that different aspect of mathematics can be found in a single game (one game-multiple concepts). This multi concept-game relationship can be a critical determinant for the selection, development or adaptation of a game for instructional effectiveness. However, few teachers indentified cultural games as involving school mathematical concepts in measurement (19.12%), shapes and space (10.29%), problem solving (8.09%), and collecting and handling data (5.15%). Findings of the study suggest that although most teachers know that some mathematics across the curriculum is embedded in cultural games, that knowledge appeared limited primarily to number and number relations. This study prompts re-conceptualization of game-based mathematics pedagogy in the mathematics curricula of primary education.

Introduction

Today in Ghana, all Basic Schools (i.e., the first nine years of formal schooling) follow a nationally prescribed mathematics teaching programme contained in the school syllabus commonly referred to as the 'mathematics curriculum.' The mathematics syllabus gives detailed prescription of what is to be taught at each level and suggests activities for teaching the curriculum content. The curriculum content includes Number, Shape and Space, Measurement Collecting and Handling Data, Problem Solving and Investigations (Ministry of Education [MOE], 1997; 2007) and framed on the principle that "there simply cannot be any meaningful development in virtually any area of life without knowledge in Science and Mathematics" (MOE, 2001, p. ii). While the curriculum is designed to focus on the development and use of basic mathematical knowledge and skills, the MOE also incorporated the philosophical goal to emphasize "indigenous mathematics" to increase its relevance for Ghanaian children (Pecku, 1998, p. 38).

In Ghana, reforms in mathematics education geared towards curriculum relevance define a changing role for the teacher. The revised curriculum states that "the general objectives can be effectively achieved when teachers create learning situations and provide opportunities that enable pupils to acquire as much knowledge and understanding as possible through their own activities" (Ministry of Education [MOE], 1997; 2007, p, 8). Teachers are also to provide opportunities for children to explore various mathematical situations in their environment to enable them make their own observations and discoveries (MOE, 2007). An area of particular interest for mathematical exploration is the use of play activities and games, particularly cultural games, in the mathematics classroom. The mathematics syllabus for primary schools had earlier allowed the possibility of using games by asserting that for the study of relationships "games and puzzles" are to be used and concepts developed

and established through practical activities (MOE, 1997, p. 5). Practical activities are to ensure meaningful understanding of mathematics. Povey, Burton (with Angier & Boylan) (2004) describe understanding of mathematics as a "socio-cultural artifact similar to language." They argue that:

> "[a]ny particular 'piece' of mathematics can be located, spatially and in time, and be 'understood' within its cultural context. … this approach [takes] away some of the mysticism and power of mathematics and relocate respect to learners, as well as those who have discovered or invented the culturally powerful tools of knowledge" (p. 43).

Cultural games, as Nabie and Nyala (2009) study indicate, do not only enhance cognitive development in ensuring the social construction of mathematical knowledge and understanding within the socio-cultural context, but also serve as an instructional tool for child-centered learning. Games locate mathematics in the social domain of children. They make mathematics learning as play and thereby demystifying the conception of mathematics as "an untouchable subject" for the average child. They provide concrete experiences for creating, testing and affirming mathematical meaning.

The use of games in mathematics education has gained support by several researchers and educators (Booker, 2004; Casbergue & Kieff, 1998; Gerdes, 2001; Hancock & Osterweil, 1996; Kamii with Housman, 2000; Markey, Power, & Booker, 2003) who believe mathematical knowledge is a personal construction from appropriate experiences. Booker (2004) advocates the use of games for developing mathematical concepts as they lay "the foundations for processes and thinking strategies that will be formalized later as well as consolidate existing thinking" (p. 16). Games as curriculum instruction materials lead directly to mathematical concepts (Powell, Cangelosi, Harris, 1998) and provide visual, auditory, and kinesthetic experiences for the construction of mathematical knowledge.

Theoretical Framework

The selection, development or adaptation of an instructional game to suit teaching and learning depends on the teachers' full conceptual understanding of the mathematics so that the game will focus on all the essential aspects (Booker, 2004). This full understanding requires a conceptual analysis of the mathematical content to be taught, the potential difficulties, misconceptions, the game structure and play format in which concepts and processes are embedded, and the relationship between the mathematics of the game and the curriculum. These requirements suggest an understanding of the ultimate mathematical value of the game or instructional material.

Recent studies of curriculum materials provide rich insights into the relationships between the materials themselves and mathematics teaching (Collopy, 2003; Remillard, 2000; Remillard & Bryans, 2004). These studies indicate that teachers' knowledge and beliefs continue to shape their interpretations and uses of curricular materials. Teachers' beliefs and values serve as a filter through which they interpret the curriculum materials. Specifically, the use of instructional materials for teaching mathematics is shaped by the teachers' orientations—"a set of perspectives and dispositions about mathematics"—that influence how teachers engage and interact with curriculum materials in classroom practice (Remillard & Bryans, 2004, p. 364). Enacting mathematics curriculum change through the use of materials requires the teacher to know their conceptual value and make on-the-spot decisions about what to select and how to adapt them in response to classroom mathematical events. Therefore, what mathematics games can teach is a critical filter in their selection and adaptation in the classroom. The mathematical judgments and decisions teachers make about games are therefore important components for a game-based instructional process.

Games in the curriculum are an opportunity to meet the philosophical goal of incorporating indigenous mathematics in school mathematics. Although a seemingly minor inclusion, the use of games has the potential for reforming experiences in the mathematics classroom and a means of personal construction of mathematical knowledge. While very little direction is given regarding the mathematical intention of the games or even the types of games appropriate, the understanding of the curriculum is that the inclusion was purposeful and that games were viewed as a means of linking classroom mathematics and indigenous mathematics.

Statement of the Problem

Although studies on primary school teachers' perspectives of games in mathematics

education indicate teachers awareness of the cognitive benefits of games (Nabie, 2008; Nabie & Nyaala, 2009), very few teachers use cultural games in their mathematics classrooms (Nabie, 2008; Nabie & Sofo, 2009). Few teachers' instructional patronage of cultural games in the mathematics classroom suggests that teachers may not know of the mathematical value of these cultural resources. As a result, pupils tend to learn mathematics as if it has no social referents, a situation that makes mathematics learning unattractive to many pupils right from their early school years. It is against this backdrop that the study was designed to explore primary teachers' mathematical conception of the cultural games played in their various communities.

Research Questions

The questions that guided the study were:

1. What are basic school teachers' conceptions of the relationships between school mathematics and that of cultural games?
2. From teachers' perspective, how is school mathematics manifested in cultural games?

Significance of the Study

While teacher education in Ghana has improved significantly, Nabie, Anamua-Mensah, and Ngwan-wara (2010) lamented the existing gap between curriculum reforms and teachers' basic mathematical knowledge for implementing reform provisions. It is against this backdrop of the existing discrepancies between curricular prescriptions and curricula realities that this study was undertaken to examine primary school teachers' mathematical knowledge of their indigenous community games for classroom practice. Consequently, this study surveyed Ghanaian teachers' mathematical knowledge of games as tools for making mathematics relevant, and playful. The study contributes to understanding what mathematics cultural games can provide and how that might inform practice in the mathematics classroom. It also provides empirical basis for decisions regarding what game to select and adapt in the mathematics curriculum development process. Understanding the mathematical values of cultural games from teachers' perspective provides a mathematical lens for developing the games for classroom instruction.

Methodology

The method used in the inquiry was descriptive research. A description of the research process is outlined as follows:

Research participants

Participants for the study included a purposive sample (Merriam, 1998) of 156 (53 males, 103 females) certificated primary school teachers from Wa Municipality in the Upper West region of Ghana. The participants were drawn from 30 out of a total of 52 primary schools in the Municipality. Schools were selected based on their accessibility

Grade levels of instruction of participants

The number of teachers representing the various primary grade levels who participated in the study is shown in Table 1.

Table 1: Grade levels of participants surveyed (n = 156)

Level	KG	P1	P2	P3	P4	P5	P6	DHT*
Number of teachers	2	26	26	24	29	20	21	8

DHT* means Detached Head Teacher. They primarily do administrative work but occasionally teach when needed.)

Teachers surveyed represented all the primary grades including Kindergarten, which recently became part of the public education , system. Participants' teaching experience ranged from six months to 36 years with an average of 12.5 years.

Research context

In Ghana, there is a nationally prescribed school curriculum for Basic School Education (first 9 years of formal schooling). Topics and activities are sequentially arranged in the nationally prescribed syllabus to guide teachers. However, teachers may re-order the topics in a way that they think will facilitate children's systematic conceptual development and understanding. The same cultural games are played in the schools and the school communities. The instructional materials to use for various topics outlined in the syllabus depend on the

teacher's mathematical understanding of the materials. The ethos of teaching is such that children virtually accept what mathematics is taught and instructional materials used without question. Essentially, children learn and practice the mathematics that is promoted by their teachers who decide what, how, and when to teach and to assess.

Data collection Procedure

A 29-item questionnaire was the instrument used in collecting data. The questionnaire was first piloted for "conceptual clarifications", and for a formal "dress rehearsal" to eliminate ambiguities in the items (Yin, 2003, p. 79). The questionnaire identified teachers who were users and non-users of games in teaching mathematics, the mathematics in cultural games, and the relationship between school mathematics and cultural games. Consented teachers were given a questionnaire and a two-week period was agreed to give their responses. A total of 164 questionnaires, constituting 68% of the questionnaires, were returned. Eight were rejected for incompleteness. Responses from the remaining 156 questionnaires constituted the data. Descriptive statistical analysis was applied to quantitative data while thematic analysis was applied to qualitative data obtained from the open-ended items of the questionnaire.

Results

The curriculum is the statutory document that defines the breadth and depth of the mathematics education programme. So analysis of the data was guided by the curriculum provisions for teaching basic school mathematics. In particular, two themes that reflect the research questions constituted the analytical frame for analyzing the data namely: how cultural games relate to school mathematics and ways in which mathematics manifest in cultural games.

Relationship between School Mathematics and Cultural Games

A teacher considering implementing games in the classroom would first have to identify the game and consider the actual mathematical content that might be learned through the game. A questionnaire item that asked teachers the games played in their communities identified several cultural games classified by their mode of play into eleven categories namely: pebble sowing, stone passing/ throwing, searching, jumping, hopping, pebble pushing, dancing, aiming, pulling, and comparing games. Other Western-oriented games such as dominoes, ludo, snakes and ladders classified as common games, which were not of interest in this study, were also identified. However, what cultural games the teacher can teach depends on the teachers' awareness of the mathematical relationships between the games and the school mathematics curriculum. Even if the teacher is aware of games as an instructional tool, he/she may decide to use them or not. Analysis of an item that explored the use or non-use of games indicated that 47% use both common and cultural games. Although approximately half of the teachers used games to teach mathematics, only 22% participants used cultural games. To gain insight into teachers' awareness of the relationship between games and the school mathematics curriculum, participants were asked: "Do you think cultural games relate to school mathematics? If so, in what ways?"

Out of the total number 156 who returned the questionnaire, 141 (90.38%) teachers responded to the item. A total of 136 (96%) of the 141 teachers who responded to the question indicated that there was a relationship between cultural games and school mathematics content. Four percent (4%) of the teachers saw no relationship between cultural games and mathematics. Of the 136 teachers who responded positively, 93% indicated specific ways in which some games address mathematics content while the rest did not. Interestingly, 50% of both users and non-users noted at least one relationship between a game and mathematics content. Table 1 reports the relationships teachers saw between school mathematics content and the categories of cultural games. The percentages of teachers who identified those relationships are also indicated.

Table 1: Cultural games identified by teachers and their relationship to mathematics (n=136)

Mathematics Content	Game classification and ways of relationship	Users (n = 74)		Non-users (n = 82)		Percentage (n=136)	
		f	%	f	%	f	(%)
Number and number operations concepts	Playing hopping, jumping, stone-passing/throwing, pebble-pushing/rolling and pebble-sowing games involve number, counting, basic arithmetic, and pre-number activities in obtaining materials.	55	74.32	47	57.32	102	75.00
Measurement	Pebble-pushing/rolling and comparing games. Constructing and playing pebble- pushing/rolling and hopping games involve measuring and drawings playing comparing games involve comparing capacities.	10	13.51	16	19.51	26	19.12
Shapes and space	Construction of pebble-pushing/rolling, some hopping games and patterns of play in most of.the games involve geometry. Dancing games involve movement geometry; hopping, pebble-pushing/rolling and marble-pushing games involve constructions.	7	9.46	7	8.54	14	10.29
Problem solving and investigations	Games involve observing, logical thinking and reasoning. All pebble sowing games involve sorting, counting; playing all games involve strategies, and communication. All games contain some mathematics skills; Counting, measuring, sorting, reasoning, constructing, etc. Games involve rules as in algebra.	6	8.11	5	6.10	11	8.09

The data in Table 1 indicate that on the whole teachers found all cultural games in their communities relating to school mathematics in some way. Of the teachers who were able to identify mathematics in cultural games, most (75%) stated that cultural games involve number concepts and number operations. Other mathematical content was mentioned for some games, but much less frequently including: measurement (19.12%), shapes and space (10.29%), problem solving and investigation (8.09%) and collecting and handling data (5.15%). In all categories except number and number operations and measurement, there is only a slight or no disparity between users' and non-users' awareness of the relationships between cultural games and school mathematics.

Ways in which mathematics manifest in cultural games

The classification of cultural games in their areas of mathematical relationships is as in Table 1. Teachers' responses to the open-ended question, "If so, in what ways?" that followed the main question "Do you think cultural games relate to school mathematics?" indicated that most users and non-users believe mathematics manifest in cultural games in three main ways: in *play*, in *construction*, and in *searching for materials*. Teachers' examples of how mathematics manifest in games in process of play, construction, and searching for materials are as follows:

(a) *The playing process:* In playing hopping games (*dansu/gollaa*) players count the number of times they win or lose and to add or subtract. *"'Baa-baa' relates to measurements and numeracy ... 'iri maa yi' relates to order of numerals and subtraction."* The player measures and draws lines when he or she wins. Also, *"when we take one of the games, for example hide and seek, marks are accumulated. The first person to find the treasure is given 100, 2nd 90, 3rd 80 and so on. These marks are added together and the person with the highest mark wins."* Similarly when playing the jumping game *(ampe)*, marks are scored. One has to keep track of the score for the first round and add scores received in the subsequent rounds. *"Cultural games introduce the pupils to measurements in filling the bottle, 'boŋsiŋ ãã'*, [a comparing game]. " As they play, they count and others record the marks.

(b) *The construction process:* In the process of "constructing" hopping games (*dansu/gollaa*) students make rectangles/squares; in the pebble-sowing game *(daha)* they dig arrays of holes; while in the pebble-pushing game (*baa-baa*) students draw lines and shapes. One respondent particularly wrote in the questionnaire that *"Constructing the game may involve drawing lines, measuring, sorting, and counting as in mathematics."*

(c) *The searching process:* Materials have to be obtained for playing most of the games especially the pebble-sowing/-pushing games. Getting some game materials may *"involve sorting, matching, ordering, and comparing as in early number work."* In the pebble-sowing game, *daha*, you sort and count the playing materials and holes. All these processes involve the use of *"mathematical language, observation* [and] *mathematics thinking"* as in school mathematics. Simply put *"cultural games provide a basis for mathematics learning. Most games are problem solving oriented, follow a pattern, and have rules. So it is mathematics."*

The evidence that teachers gave about the mathematical content of specific cultural games and their relationship to school mathematics suggest awareness of the mathematics in cultural games.

Discussion

Prior to the 1987 comprehensive education reform in Ghana, mathematics education was theoretical and based entirely on the transmission model of instruction at all levels. The revised curriculum resulting from educational reforms within the constructivist perspective recognizes learning as a social activity and encourages a more interactive and explorative approach to knowledge construction. Cultural games are seen as a social means of constructing mathematical knowledge. The types of cultural games identified and classified by teachers and their relationship to school mathematics (see Table 1) confirms that real mathematical issues arise out of cultural games (Booker, 2004; Smith, 2006). In particular, number and number operations which cut across the entire primary mathematics curriculum can be experienced in hopping, jumping, pebble/marble pushing, stone throwing/passing, and pebble sowing games. Indeed 75% of the teachers recognized the number and number operations potential of these games played their communities. Also, the pebble pushing/rolling and hopping games are identified to relate to all the primary

mathematical content domains delineated by the curriculum. Specifically, these games involve counting, measuring, constructing shapes, reasoning, and the possibility of winning or losing a game in play which involves chance. Interestingly, few teachers indentified cultural games as involving school mathematical concepts in measurement (19.12%), shapes and space (10.29%), problem solving (8.09%), and collecting and handling data (5.15%).

One could argue that most teachers are simply not aware of the mathematics in games and, as a result, do not consider them valuable for learning mathematics. However, almost every teacher in the study could identify at least one relationship between cultural games in the community and school mathematics content. This result provides further evidence that there is a difference between knowing what and knowing how. Thus, it "is not just what mathematics teachers know, but how they know it and what they are able to mobilize mathematically in the course of teaching" that can provide a foundation for pedagogical action in craft practice (Ball & Bass, 2000, p. 95). Conceptual awareness is not a substitute for pedagogical awareness. In other words teachers lack rigorous knowledge of the mathematical grammar of most of their community games. This lack of knowledge tends to influence teachers orientations on the use of cultural games as tools in their mathematics instructional practice (see Table 1)

All cultural games are found to involve mathematical skills for problem solving skills which is at the heart of the mathematics curriculum. These skills include observing, logical thinking, counting, sorting, measuring, and constructing. The fact that only 8.9% of the teachers saw the potential of cultural games in this relationship suggests that although they know the skills involve in the games, many do not recognize the skills in the act of solving problems. One interesting key feature of the study is that in all the content domains more non-users tend to conceptualize the mathematics of cultural games than the users. In spite of these contrasting user non-user differences, cultural games provide the context for learning and understanding mathematics in action.

Games are incorporated in the curriculum with the intention that teachers will use them as alternative tools of instruction to make mathematics relevant, accessible, pleasurable, and memorable to children. In the study, all the teachers indicated some mathematical relationship between school mathematics and cultural games. Teachers indicated that different games can embody the same mathematics (multiple games-one concept relationship) and that different aspects of mathematics can be found in a single game (one game-multiple concepts). This multi concept-game relationship can be a critical determinant for the selection, development or adaptation of a game for instructional effectiveness.

Multiple mathematical concepts in cultural games provide an excellent opportunity for multiple conceptual learning while multiple games for a single concept can provide an excellent space for the choice of game that can meet the cognitive and ability level of diverse learners. Teachers' interpretation of the relationship between cultural games and school mathematics in the study is consistent with several findings (Barta & Schaelling, 2001; Gerdes, 2001; Zaslavsky, 1979) that cultural games embody school mathematical concepts and therefore provide rich mathematical opportunities for teaching and learning mathematics.

In comparative terms, the hoping game is known by teachers to be more mathematical. Teachers seem to have a full mathematical understanding of this game as they are able to identify its mathematics across all the content domains delineated by the curriculum. This suggests relativity in teachers' mathematical understanding of the games. Relativity in understanding the mathematics of an instructional material can influence the choice of selecting, development or adapting the material for classroom instruction.

Games have rules under which they are played. They also have structures under which they are designed and depending on the game, the design structure and mode of construction of cultural games can easily be translated into mathematics. All the games the teachers identified lead to various mathematical concepts and skill consistent with earlier studies (Booker, 2004; Markey, Power, & Booker, 2003; Swan & Marshall, 2005) and the development of mathematical language.

Mathematical constructions arise in the social sense-making in playing game, constructing games and game material searching processes an understanding that mathematics concepts and processes arise in game structure and play format. Generally, teachers in this study identified three

interactive aspects in game-play and design structure through which individuals construct mathematical knowledge, share knowledge and make meaning of the knowledge. In particular they recognized that in the game construction process, some may involve geometrical shapes and measurement in Euclidean geometry; concepts and skills such as rectangle, line, square, in the playing process; and pre-number skills among others in the game searching process that cut across the construction and play processes such as mathematical thinking and measuring. The skills identified in cultural games are fundamental to understanding basic school mathematics. Identifying and relating the mathematics of cultural games to school mathematics is a manifestation of teachers understanding of the mathematical content of game design structure, play format and material procurement in which concepts and processes and the relationship between school mathematics and games in the curriculum.

Although teachers conceptualize mathematics in cultural games, their conceptualization is very limited. Majority of the teachers see some mathematical relationship between school mathematics but do not have rigorous knowledge of the mathematical content or grammar of games in measurement, shape and space, problem solving and investigations, and collecting and handling data. The limited conceptual knowledge of the mathematics embedded in the games can negatively impact their use for classroom mathematics teaching.

Conclusion and Recommendations

Cultural games are a valued part of the cultural heritage of Ghana and many games are rich with mathematical content. Not only do cultural games provide children with opportunities to learn, but the study revealed that teachers could benefit from their awareness of the mathematics in games. Most participants in the survey recognized that mathematics across all curriculum strands is applied in playing cultural games; however, that knowledge appeared limited primarily to number and number relations content. This finding prompts reconceptualization of the use of games in teacher education including in-service mathematics teacher education and an in-depth research of the mathematics cultural games can teach. If the curriculum values the mathematics of cultural games in the mathematics classroom, efforts must be made to make teachers know the mathematics in them. The findings suggests that by involving students in developing lessons that incorporate the use of cultural games in teacher education, teachers' can learn the mathematics embedded in the games through three preparatory activities: in searching for the game materials, in constructing the games, and in playing the games. It is important that teachers recognize and incorporate the principles of cultural games in math tics teachers professional development experiences in these three dimensions to enable teachers' link classroom mathematics to children's everyday play life.

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