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Science and mathematics teaching through local games in preschools of Botswana

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This article presents a study regarding preschool teachers' skills and competencies in teaching science and mathematics. The aim of the project was twofold; one to find out the preschool teachers' knowledge about mathematics and science concepts and then to develop support material to empower them with skills and competencies to teach these concepts in preschools. A qualitative approach was adopted, and a case study method was used. Data were collected through two workshops and focus group discussions with preschool teachers. The study revealed that the preschool teachers had content knowledge, but lacked pedagogical knowledge that is crucial in teaching of preschool children, and they provided science and mathematics experiences in preschools scarcely. A resource book of 33 local games and rhymes thus was developed as a support material to empower the teachers with skills and competencies to use play to teach science and mathematics in preschools. The resource book developed consists of 33 local games/rhymes and is packaged with the games' illustrations, steps and rules followed in the games, science and mathematics concepts and competencies that could be taught to children, along with probing questions that would help in teaching of science and mathematics concepts to children.

Introduction

The Primary School Leaving Examinations results of Botswana show learners' poor performance in science and mathematics. Similar results are seen in Junior and Senior secondary schools, and at tertiary level the learners either avoid taking mathematics and/or science subjects or they do not manage to sail through smoothly when they take them. Thus, the learners' preparation needs to be looked into and, early childhood (EC) being the foundation level, needs to be probed as early as possible. The existing preschool practices need to be assessed; the teacher's knowledge, skills and competencies in teaching/learning of science and mathematics need to be examined; and support materials have to be provided, if necessary. This research intended to find out whether the preschool teachers have knowledge about mathematics and science concepts that are embedded in local games and to empower them with skills to teach science and mathematics concepts, through the development of a resource book. In order to develop such resource materials for preschool teachers, it is imperative to understand the developmental process of science and mathematics concepts in preschool children.

Preschool children's experiences with science and mathematics (curriculum and role of teachers)

Children's understanding of scientific and mathematical concepts grows during EC as the majority of brain development takes place during these years, and most rapidly (Berk 2002). Children are curious and can be encouraged to develop scientific thinking and learn about emerging mathematical and scientific concepts. Children's curiosity, motivation and sense of mastery are the key to success in the early years (Chang, Stipek & Garza 2006; Singer, Golinkoff & Hish-Pasek 2006). During the early phase, they actively explore their environments, indulge in process of inquiry, discover certain concepts, get stimulation to form ideas, develop thinking, classify information, reason out actions, solve problems and make decisions and construct their own knowledge. An early enthusiasm in mathematics and science during this impressionable age can build-up the foundations for later competencies so that they can use informal mathematical and scientific knowledge developed before they entered school to organise their formal school environment (Essa 2011). In order to do that, teaching/learning of mathematics and science concepts should form an integral part of daily life activities in EC, and the preschool curriculum should include activities, while being careful about the similarities and distinctiveness between different geographic and cultural groups, such as counting, measuring, locating, designing, playing, exploring, problem-solving, observing and classifying for higher gains in various domains (Bishop 1991).

Ideally, an environment should be provided for children to deal with activities related to numbers, length, area, volume, weight, colour, function, shape, geometric features, patterns and texture along with hands-on materials to believe and see it happen, as science is not intuitive. The ability to ask questions, recognise relevant details and use a combination of observation and inference to generate evidence-based explanations need to be encouraged to enhance science process skills in children. Activities that are able to control variables, generate and interpret evidence, formulate models, measure and communicate ideas while clarifying meaning, classifying and predicting and recognising causality should be part of the EC Education (ECE) curriculum. Ideas such as uncertainty, probability, necessity, sufficiency, and forming and testing a hypothesis should be available to children and they should be able to design experiments and revise hypotheses. Tools that enable testing of various concepts of living and non-living things should also be included in ECE classrooms (Gallenstein 2005; Lehrer & Schauble 2006). In short, a developmentally appropriate programme with context that increases progressively in conceptual depth and complexity as children advance through school and life needs to be made available in ECE settings with relevant resources and time to use them (Clements 2001; Lind 1999).

The teachers' role is undoubtedly very important in planning, supporting and guiding children in learning about maths and science concepts. They can use various teaching strategies and techniques such as modelling and providing feedback and cognitive structuring in an environment that encourages learning through social relationships (Fu 2010). An effective EC teacher should be one who can facilitate and extend children's learning within the holistic nature of the EC curriculum without being overcome by the traditional teacher-centred method that inhibits children's active participation (Kallery & Psillos 2001). Children enter preschool with a range of concepts gathered from informal experiences (Darling-Hammond 2000) and early educators need to use them in teaching/learning process and create a learning environment that gives children opportunities to develop fundamental values, skills and understanding of various aspects. A strategy that makes teachers active participants with children who are active and inventive rather than simply transmitting knowledge to passive children is necessary to make the learning better (Garbett 2003). Employment of an innovative, ground-breaking strategy that not only warrants novelty but also facilitates early understanding and interest and mastery of concepts thus would make science and mathematics teaching interesting, easy and enjoyable both for the young ones and the teachers.

Play as strategy for science and mathematics education

Play in children is a powerful tool and is a predictor of optimal early learning and future success in life (Grand Fun Alley Learning Center 2014). Children of all ages love to play, which gives them opportunities to explore the world, interact with others, express and control emotions, develop their symbolic and problem-solving abilities, be self-regulated and practice emerging skills. Hands-on activities and problem-solving situations can arouse children's curiosity through play (National Association for the Education of Young Children (NAEYC) 2009). Play is an activity for enjoyment and recreation rather than for serious or practical purpose and game is competitive or a sport that is played as per rules. Play and games are closely related to childhood and provide children with opportunities to be creative and build-up abstract thinking in them. Kagan and Lowenstein (2004) propose that a combination of systematic instruction methods and game-based learning can increase the effectiveness of the curriculum, as it is not only an active learning method but also a cooperative and community-based method, which refers to methods of instruction where students work in groups to complete tasks collectively towards academic goals. Play can form an important base for all teaching/learning process of mathematics and science (Johansson & Pramling Samuelsson 2006) and can develop interest both in teachers as well as in young children in EC classrooms as through play children interact with one another naturally (Moomaw 2011).

At preschools, rhymes and songs on the other hand come to life during circle times as preschool children show word meaning through simple actions and finger movements. Preschoolers develop memory and recall skills as they sing and recite songs and rhymes and find it fun and exciting to explore the world of language while moving their fingers, arms and bodies and singing songs and action rhymes. Rhymes and songs are important early activities that spice up learning with fun and could be included as parts of the pleasure-giving play activities that the children indulge in the preschools of Botswana.

Children are usually told stories and they actively participate in songs, dances, art traditions, celebrations, beliefs and values that are unique to their culture and experience in most of the preschools. Playing games and singing rhymes that are rich in cultural beliefs, values and norms can be a good source of enjoyment, and through them, the teachers can teach science and mathematics concepts to the young children. A teacher needs to make use of opportunities to integrate this rich cultural diversity into the curriculum and weave it into the fabric of everyday school life. Playing local games especially in early years develops children's values, morals and ethical standards and can provide a rich experience to the children. Therefore, the present study explores the advantage of using play in teaching/learning of mathematics and science in preschool, as an innovative strategy.

Theoretical/Conceptual framework

This article is informed by several theoretical perspectives, namely Shulman's notion of pedagogical content knowledge (PCK) that includes pedagogical knowledge and content knowledge (Hlas & Hilderbrandt 2010), Piaget's cognitive theory of play and Vygotsky's socio-cultural theory.

Shulman introduced the notion of PCK and believed that teacher education programmes should combine the PCK, which means the 'how' of teaching to structure and represent academic content, and the content knowledge, which is the 'what' of conceptions, misconceptions and difficulties that students encounter when learning particular content, along with knowledge of the specific teaching strategies that can be used to address students' learning needs (Hlas & Hilderbrandt 2010). Shulman believed that teachers' subject knowledge and pedagogy were mutually exclusive, and the teacher education programmes need to combine the two knowledge fields to guide their actions in highly contextualised classroom settings.

Piaget, on the other hand, sketched the broad outlines of evolution of children's play in the first 7 years (sensorimotor and pre-operational stages). He emphasised that play is not the same as learning but provides a relaxed atmosphere in which learning can easily occur through assimilation and children can construct knowledge by taking something and making it fit to what they already know. He saw the importance of symbolic play in the formation of children's mental representation and abstract thinking and talked about sensorimotor or physical play where children repeat a physical activity, such as swinging their feet or throwing their head back, for the sheer enjoyment of doing it. Games of construction and games with rules were also emphasised by him (Essa 2011).

The socio-cultural theory of Vygotsky stressed that the children are active seekers of knowledge and not solitary agents, and their collaboration with the social environment moulds cognition in culturally adaptive ways through social agents such as parents, teachers and peers and through other materials. He said that the social agents provide a temporary platform or support (Scaffolding) through which children can accomplish a range of tasks that are within their Zone (Zone of Proximal Development) and cannot yet handle alone. He also emphasised that play promotes abstract thought that allow children to reach beyond their actual development in their cognition and self-regulation and achieve a mental representation of social roles (Essa 2011).

Thus, the present research is informed by all the above-mentioned theories that emphasise the teachers' PCK and content knowledge; the cognitive development of children through symbolic play, games of construction and games with rules; and the construction of culturally adaptive knowledge of children through social agents such as teachers and peers and other materials. Integration of play can maximise learning and make children learn mathematics and science in natural ways as part of everyday life and can satisfy them and can bring excitement and relief from tension and anxiety of learning difficult concepts of science and mathematics. Play can give joy and amusement and can increase the level of learning. Thus, the notion of teacher education becomes inevitable here, because teachers need to have the understanding that along with the content knowledge, pedagogical knowledge is essential, and that the use of an innovative strategy that can make teaching/learning of science and mathematics enjoyable and easy is crucial. The notion of teacher empowerment also needs to be emphasised here. If the teachers do not have the necessary education, then they need to be empowered with skills that would enable them to make their jobs more fulfilling and less difficult and help in school improvement and benefit the children. In addition, they need to develop their range of tasks as they often begin to tire of doing the same things years together, offering the same activities, which might become insufficiently interesting, and need renewal and refreshment to teach the children effectively. Thus, extending one's professional role in order to improve one's teaching, one's work life and the school as a whole is very important. It helps in building up one's professionalism and achieves more effective teaching with enjoyment. Provision of more resources and opportunities empowers teachers; thus, this research draws heavily on the concept of teacher education, teacher empowerment and the effectiveness of support materials.

Early Childhood Education in Botswana: A disadvantaged sector

Botswana is a country rich in resources; however, the ECE sector could be termed as a disadvantaged sector, which is gradually receiving attention. The government of Botswana has introduced 120 preschools to the existing primary schools only in 2014. Before that, ECE was dominated by private sector, mostly with untrained teachers, and with no national curriculum to follow, as it was also introduced as late as 2014, by the Ministry of Education and Skills Development. In addition, the preschools that are available are clustered mostly in urban and semi-urban areas. Access to ECE is scarce in remote and rural areas, especially with lower socio-economic conditions, and, if available, has an acute shortage of both human and physical resources (Bose 2008a; 2008b). As a result, teaching and learning in most of the preschools is of low quality.

Preschool education is the key to increasing all children's school readiness and to closing the achievement gap (NAEYC 2009). Science and mathematics education, among other areas could be important factors to combat the above, which receive very little attention in the early years. Botswana is no exception, and more attention needs to be paid towards this. Therefore, it was necessary to undertake a study on the existing practices in preschools in Botswana regarding the teachers' knowledge base and the children's engagement in mathematical and scientific experiences, in collaboration with the Swedish International Development Cooperation Agency (SIDA).

The Swedish International Development Cooperation agency: Office of research and development project

This partner-driven cooperation project (2012–2014) between University of Gävle (UoG), Sweden and University of

Botswana (UB) was initiated to find out the *Subject Matter Knowledge and Pedagogical Content Knowledge* of ECE teachers in mathematics and science in Botswana, to improve teachers' knowledge base and to establish a sustainable Science Centre in UB in cooperation with UoG and North West University, South Africa. The study was funded by SIDA and the Office of Research and Development (ORD) of UB. As part of the SIDA-ORD project, a needs assessment study was conducted to find out the status of mathematics and science education in preschools of Botswana. The study revealed that a majority of the teachers were not trained in ECE and revealed that around 86% of the teachers did mathematics- and science-related activities outdoors, and almost 50% of the participants faced challenges while teaching mathematics and science to preschool children (Bose, Tsamaase & Seetso 2013). The study further revealed that though the majority claimed to have done mathematics- and science-related activities outdoors, very few could articulate them clearly, and when they could, indicated a clear inclination towards counting activities, identification of shapes, number games, etc. Science-related activities such as living/non-living things, observations, planting seeds, nature walk, etc., were planned scarcely. The majority of preschools had mathematics and science corners within the classrooms, though under-utilised, as children hardly played there. Instead, the teachers indulged in activities mostly outside the classrooms, in a formal way. Observation of these ECE centres also revealed a similar trend where the children were hardly found to be engaged in any science or mathematical activities inside or outside the classroom. Perhaps the skill necessary for planning and playing within the classroom was lacking as most of them were not trained in ECE or lack of motivation caused it (Bose 2008; Bose *et al*. 2013). The study also recommended that preschool teachers in Botswana need in-service training and support material to teach science and mathematics in preschools. Workshops, short courses and development of a resource book for the preschool teachers to provide guidance, knowledge and skills on the use of mathematics and science activities for preschool teachers were recommended strongly.

The present study

The researchers realised that children learn in a variety of ways and wide range of teaching strategies and interactions can be effective in supporting mathematics and science learning in preschools. They understood that teaching/learning of mathematics and science concepts through play would be easier and exciting for young children and would provide the cultural flavour of Botswana. Thus, they aimed at finding out the teachers' knowledge regarding mathematics and science concepts that are embedded in the local games played in preschools and empower them to teach science and mathematical concepts to the children in a playful manner. The specific objectives of this study were as follows:

1. To find out the preschool teachers' knowledge regarding mathematics and science concepts embedded in the local games, played by preschool children
2. To develop a resource book of local games to empower them with skills to teach these concepts in preschools.

Research Methods and Design

A qualitative approach was primarily used. The researchers chose a case study method for collecting data/information. In social sciences, a case study is a descriptive, exploratory or explanatory analysis of a person, group or event. An explanatory case study is used to explore causation in order to find underlying principles. This approach is tangible, illuminative and more concrete as compared to other kinds of researches, as it describes the process and the context of the study and focuses on a particular phenomenon, such as a situation or an event (Gay, Mills & Airasian 2009). It can help in understanding complex inter-relationships and are grounded in 'lived reality' can facilitate the exploration of the unexpected and unusual and enable one to focus on the significance of the idiosyncratic and finally can facilitate rich conceptual/theoretical development (Hodkinson & Hodkinson 2001).

On the other hand, the case study approach has certain limitations such as it deals with theoretical knowledge and often fails to generalise and, hence, cannot contribute to scientific development and is difficult to summarise specific case studies (Flyvbjerg 2006). It also is very expensive for a large sample size, has too much data, hinders easy analysis, is strongest when researchers' expertise and intuition are maximised and raises doubts about their 'objectivity' (Hodkinson & Hodkinson 2001). However, the researchers of the present study felt that the case study approach was the most appropriate as the sample was not very large, and it focuses on the particular context, the teaching of Science and Mathematics to preschool children of Botswana through local games and explains the process of teacher empowerment.

In this study, a prospective approach was used where the criteria were established and cases fitting the criteria were included as they became available, rather than a retrospective approach where the criteria are established for selecting cases from historical records for inclusion in the study (Best & Khan 2006; Gay *et al*. 2009). Development of a resource book was the criteria in this research that was already laid down, and the components to be packaged in the resource book were the cases that were included after conducting the workshops.

Involvement of ECE teachers was most probable and important. A purposive sampling technique was adopted, and the researchers invited teachers from all the regions of Botswana for a true representation of urban, semi-urban, rural and remote areas. They conducted two workshops during 2013-2014 in Gaborone, Botswana (Best & Khan 2006; Gay *et al.* 2009). Focus group discussions and group work were used as data collection instruments. The first one was a consultative workshop conducted in 2013 for 2 days. For analysing demographic data, the researchers used quantitative analysis.

Twenty-five (25) preschool teachers participated from all over the country. Thirteen (13) were from private institutions, five from council, four from church and three from non-governmental organisations (NGO). Only 36% of

teachers had a certificate in ECE, the rest had diploma (9) in primary education, junior certificate (2) or Cambridge O Level secondary certificate (5). One-fourth of those who held ECE qualifications were foreigners (6), but the rest were from Botswana. Almost 50% representation was from the private sector. This depicted a true picture of Botswana where the ECE teacher training centres are slowly emerging, and most of the trained teachers are expatriates, who come from neighbouring countries (Bose 2008a; 2008b).

The second workshop was a review workshop conducted in 2014 for 2 days, where 27 teachers participated from all over the country. Efforts were made to invite the same participants who attended the first workshop; however, only 17 of them were common. Ten (10) were from private institutions, four from council, three from church, three from NGOs, and seven were from a government preschools which were introduced recently. Only 41% of the participants were trained in ECE, five had certificates in ECE and six had diploma in IECD. The rest had diploma in Primary Education (5), PTC (2), Cambridge O Level secondary certificate (1), form-three qualifications (3) and degree qualifications such as BEd (3) and MEd (1). Of the 27, only two were foreigners and the rest were from Botswana.

Any research project involving human participants needs to follow ethical guidelines (Best & Khan 2006), and the researchers took every possible effort to follow that. They also took permission of the subjects and approval of the ministry and the institution to conduct the present research. Before starting the focus group discussions and group work as part of the workshop, they made the purpose of the study very clear to the participants, that is, teacher education and empowerment, and the development of the support material. During the workshop, the teachers listed games, rhymes and activities they did with the children in their schools. The participants played their childhood games, some of which are played through generations depicting Botswana's culture, and other common ones picked up from the neighbourhood countries (see Figure 1).

Source: Picture taken during the Workshop at Gaborone, Botswana (photos taken by Godwill Sebadieta)

FIGURE 1: Participants playing different games.

In this study, protocols were enacted to make the participants an equal partner, by maintaining ethical and professional relationship and avoiding any power differential between them and the researchers (Christensen 2004; DeRoche & Lahman 2008; Lahman 2008; Scantlebury 2005). The participants were empowered by being given opportunity to express themselves throughout the workshops as evident in Figure 1, where they are playing the games of their own choice without any control from the researchers. They were allowed to come up with all the games that they preferred, hence assuming ownership of them games, and were given an equal chance to participate in the whole study.

During the consultative workshop, deliberations were video recorded and photographed with prior permission of the participants.

The focus group data collected through the workshops were analysed qualitatively using explanation building technique for the descriptive case study (Gay *et al*. 2009; Yin 2003) in order to describe the real-life context in which it occurred. In this case, it was the teaching/learning of scientific and mathematical concepts in preschools. Data analysis in case studies proceeds from general to specific concepts and involves an iterative, spiralling or cyclical process that gives rise to recurring themes, patterns and categories (TESOL International Association 2015). In this research, data analysis began during focus group interviews and group activities in workshops and continued till the transcription of the data. Analysis involved coding of data that were transcribed from the notes, interpretation of data established the themes of PCK of preschool teachers, teacher education and empowerment, and the discussions were linked with the themes that evolved out of the analysis.

On completion of the review workshop, an audio-visual CD of the games was presented to the participants, in order to encourage them to share some local games with each other and enhance the scientific and mathematical skills in the young ones.

Results and Discussions

Teachers' knowledge of mathematics and science concepts embedded in local games

During the 2-day consultative workshop, the preschool teachers identified 33 local games/rhymes that are most commonly played in preschool and are listed in Table 1.

The research revealed that the preschool teachers did have the content knowledge, that is, the knowledge of science and mathematics concepts, and they always taught mathematics and science activities, by means of conventional method of using teaching aids to teach science and mathematics concepts inside and outside the classrooms, but never used the above-mentioned games as a via media to teach science and mathematics concepts. They did not know that mathematics and science concepts were embedded in local games and could be taught simply by playing them. For example, some said:

> 'We do teach mathematics and science and plan for activities and use charts that are readily available or prepare them ourselves. But we never use games to teach these concepts.'
>
> 'I am playing these games with children for the last 25 years and yet never understood that I am teaching them science and mathematics also at the same time.'
>
> 'Now I realise that teaching of mathematics and science could be so simple and easy.'
>
> 'This kind of workshop should be organised more often to empower us with knowledge and skills for teaching science and mathematics in preschools.'

In other words, the preschool teachers lacked in PCK and needed support to empower themselves with pedagogical knowledge to guide their actions in contextualised classroom settings. It was found that with support, in this case that of the workshop facilitators, the preschool teachers could identify the science and mathematics concepts that were embedded in the local games and could understand how those concepts could be taught while playing the games following certain guidelines. In the game *Ao Marex? Hoi hoi!* (see Table 1), for example, the participants identified concepts such as counting, pairing, size, speed, shape, weight, animals and balance. With support, they recognised the innovative strategy of using play and empowered themselves with knowledge and skills of teaching science and mathematics concepts through play.

Application of Schulman's theory of combining content knowledge and the pedagogical knowledge, Piaget's and Vygotsky's theory of construction of knowledge and cognitive development through play and acquisition of knowledge through social agents in a culturally approved way is vivid here and can well explain the outcome of this research. Evidence of teacher empowerment through support endorsed the development of a resource book as a support material for the ECE teachers of Botswana.

Development of a Resource book of local games for teachers

The preschool teachers opined that each game/rhyme needs to be packaged with a picture that depicts the game in a symbolic way, accompanied with preparatory guidelines, steps that describe how to play the games, essential rules to be observed, the science and mathematics concepts that could be taught while playing or singing and a few probing questions to make the children understand the science and mathematics concepts. Among the 33 identified local games, following are a few examples that depict how science and mathematics concepts feature in them:

Mmmupudu

It is the name of a well-known traditional wild fruit. When it has borne a lot of fruit, its branches hang down. The rhyme teaches children about this popular traditional, local fruit and at the same time about the falling of branches with fruits

TABLE 1: List of games and their meanings.

Number	Name of the game/rhyme	Meaning of the game/rhyme
1.	Ao Marex? Hoi hoi!	Players take turns to ride on each other's back.
2.	Bomme ba kati bakKati ba Kana!	A pair of players claps each other's hands. Pairs do it at the same time.
3.	Digogwane tse tlhano (Five Little Frogs)	Five frogs jump into a pond one by one until none is left. Game teaches subtraction.
4.	Diketo	Players subtract and add stones during play.
5.	Dikonyana Dikonyana! (Baby Sheep)	Playing as lambs, children identify their body parts.
6.	Dinonyane tse pedi (Two Little Birds)	Two birds ordered to fly away and fly back again.
7.	Diphiri (Wolves)	Children want to go home, but wolves prey on them.
8.	Ene ele Tshepo	A boy is milking a cow, which kicks the bucket and the milk spills on sand.
9.	Follow the leader	Players follow the instructions of a leader to perform different actions.
10.	French skipping	Skipping using a closed rope made from soft material such as old stockings.
11.	Ke lephoi mokunkuru	The lamentation of a dove that is always hunted by boys.
12.	Hoki	A bored piglet in a cage comes out, is barked at by dogs and runs back inside.
13.	Hop scotch	Four-sided shapes drawn on the ground to denote shapes, distance and directions.
14.	Jack and Bass	One blindfolded player locates other players using the senses of touch and hearing.
15.	Ka bona bona selo! Eng?	The leader says that he or she can see something and others looking at the same direction ask: What is it?
16.	Ke mang yo o tla nyalwang ke kgosi? (Who Will Be Married By The Chief?)	Identifying the one who will be married by the chief.
17.	Kgomo (Cow)	A young boy wonders who will milk his father's cow because he is too young to do it himself.
18.	Koi	Skipping.
19.	Leboko la ngwana	A child narrated how his/her mother nurtured him/her from infanthood.
20.	Mabele (Sorghum)	Red sorghum which needs to be pounded so that chaff is separated from the sorghum meal.
21.	Malepa (String Patterns)	Patterns made from soft string such as wool using fingers.
22.	Mango tree	The usefulness of a mango tree.
23.	Mmmumpudu oa wa	A wild fruit tree which is weighed down by lots of fruits.
24.	Mmutlanyane (Small Hare)	Rhyme about parts of a hare.
25.	Molelo o a sha ko thabeng (Fire Is Burning at a Hill)	Burning bush on hill.
26.	Mosadi o teng	A song about a proud woman.
27.	Nna nka ipatlela tsala yame	Competing to run faster than the other around a circle.
28.	Silasila Mealie Meal (Pound The Corn)	Advising a lady to pound corn lest she loses her lover.
29.	Tamati so, so, sosososo	Performing actions using different body parts.
30.	Terena choochoo (Chuku Chuku)	Train movement and the sound it makes when in motion.
31.	Tlou (Elephant)	Description of body parts of an elephant.
32.	Who stole the chicken from the cookery pot?	Passing the buck when asked who stole the chicken.
33.	Yo mongwe o teng, le nna ke teng!	Imitating different actions by the leader.

because of heaviness and swinging branches. After singing the song, the teacher asks the children a few probing questions regarding swinging in different directions, light and heaviness, wild or home-grown fruits, parts of the tree, etc. All these lead to the understanding of science and mathematics concepts.

Sila Sila Mmele Mele

The rhyme is about the manual pounding of corn using two stones. This was a traditional practice before the advent of milling machines, which children learn about when playing the game. Along with it are the concepts of texture, particle, size, big and small, which teach mathematics and science.

Ke Lephoi Mokunkuru

In this rhyme, the dove complains about young boys who usually kill the species of dove. Traditionally, young boys used to hunt birds, kill and eat them. In this rhyme, there is a mention of the dove's old age and the boy's young age of, which could be used to teach the number concept.

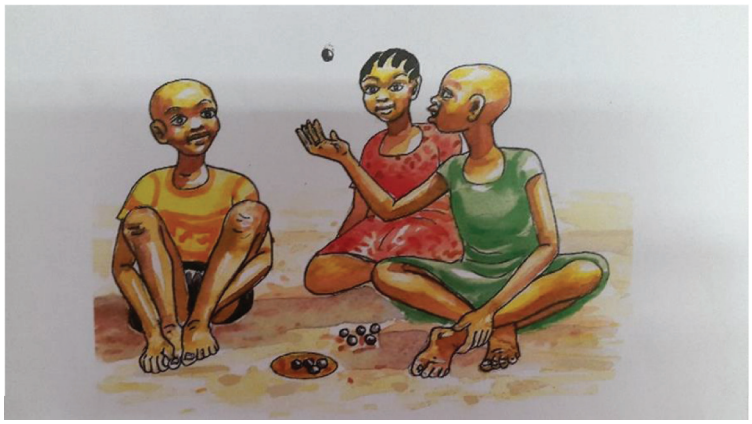
An example of how 33 local games are packaged in the resource book is shown in Figure 2.

Figure 2 shows how the game Diketo is presented in the resource book with Steps, Rules, Science and Mathematics concepts such as Addition, Grouping, Height, Shapes, Subtraction, Gravity, Living and Non-living things, Parts of the body, Texture and the probing questions.

Conclusion

Research showed that preschool teachers of Botswana hardly ever provided science and mathematics experiences in preschools. The aim of the research was to find out the preschool teachers' PCK of mathematics and science, that is, their content knowledge and pedagogical knowledge and to develop support material, a resource book, by providing guidance to teach these concepts using local games and rhymes. It emerged that the teachers had content knowledge but somewhat lacked in pedagogical knowledge. The preschool teacher used conventional methods of teaching the content, by using teaching aids. They never realised that the games/rhymes, which the children partake every day, could be utilised for teaching science and mathematics concepts that are embedded in them. They lacked in pedagogical knowledge and thus required support material to comprehend that the use of play/rhymes, the innovative method of teaching

DIKETO



Getting Started

1. Find a safe area inside or outside the classroom;
2. They collect five to ten small stones, and one slightly bigger or main one;
3. The game is played by one or two children at a time;
4. They dig a small fist size hole on the ground.

Steps

1. Players place the small stones in the hole;
2. One player plays at a time;
3. Each player holds the main stone in one hand;
4. Using one hand, the player throws up the stone in the hand and immediately scoops the remaining stones out of the hole, using the same hand;
5. The player catches back the thrown up stone;
6. The player throws up the stone in the hand again and immediately puts back the stones on the ground back into the hole in groups of ones, twos, threes or fours, up to ten;
7. Players take turns to play.

Rules

1. If the thrown up stone falls on the ground, outside the hole, another player gets a chance to play;
2. If the stone falls into the hole the player continues to play;
3. If the player fails to put the right number of stones in the hole, then another player gets their turn;
4. The first child to complete grouping the stones wins the game.

Mathematics Concepts

1. Addition
2. Grouping
3. Height
4. Shapes
5. Subtraction

Science Concepts

1. Gravity
2. Living and Non-living things
3. Parts of the body
4. Texture

Questions on Mathematics

1. How many stones were used to play the game?
2. How many stones were taken out of the hole at a time?
3. How many stones were put back inside the hole at a time?
4. How many were left outside the hole each time?
5. Where were the stones thrown?
6. How high were the stones thrown?
7. What was the shape of the hole that was dug?

Questions on Science

1. What was the texture of the stone?
2. Did the stones go up forever?
3. What made the stones drop down?
4. Which parts of the body were used while playing the game?
8. Are stones living or non-living things? Give reasons for the answer.

Variations

Different number of stones can be used to play the game.

Competencies:

- **Concept 1 (Concept of Numbers): 4:1:1 ,4:1:2 .4:1:3**
- **Concept 2 (Mathematical Skills): 4:2:1 ,4:2:2**
- **Concept 5 (Science Process Skills): 4:5:1**
- **Concept 7 (Living and Non-Living Things): 4:7:1**

Source: Bose, K. & Seetso, G., 2016, *Science and mathematics through play: A resource book for early childhood education teachers in Botswana*, University of Botswana, Botswana.
FIGURE 2: A local game as presented in the resource book.

instead of the conventional ones, is effective to deliver difficult contents of science and mathematics to preschool children. This endorsed the provision of a resource book to empower the preschool teachers with the new knowledge, skills and competencies. The awareness of combining the content knowledge and the pedagogical knowledge enabled them to develop a resource book with 33 local games/rhymes, packaged with embedded science and mathematics concepts, illustrations, steps, rules and probing questions.

It could be implied that the use of such a resource book with local games and rhymes can give the teachers a great start on

teaching mathematics and science in preschools and make the children relive their cultural values and beliefs. Through such a resource book, the preschool teachers can help children understand, through enjoyment, the embedded science and mathematical concepts that are difficult to grasp otherwise, prepare them for formal schooling and bridge the achievement gap in mathematics and science at subsequent levels. An inference could be drawn out from this research that all the preschool teachers in Botswana could benefit from this resource book and build-up knowledge, understanding, skills, competencies and attitudes related to teaching of mathematics and science in preschools. However, conducting a survey research involving a larger sample is necessary in order to generalise the research outcomes and also to assess the impact on the teachers' knowledge and classroom practices. Addition of few more local games/rhymes to the resource book could be considered, as per the contextual requirements.

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Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

Authors' contributions

K.B. was the coordinator of the project PCK and SMK in Mathematics and Science Education in ECE and organised the workshop for development of the Resource Book. She facilitated the sessions during the workshop. She wrote the Resource Book with the co-author. She made major contribution to the development of the manuscript in terms of writing, analysing and interpreting data, organising the content, and adding and formatting the text and pictures. G.S. was a facilitator during the workshops; wrote the book with the other author and translated the vernacular text in the book to English. She also carried out part of search for literature, referencing and analysing data for the article.

References

Berk, L.E., 2002, *Infant and children: Prenatal through middle-childhood*, Allyn & Bacon, Boston.

Best, J.W. & Kahn, J.V., 2006, *Research in education*, Pearson, Boston.

Bishop, A.J., 1991, *Mathematical enculturation: A cultural perspective on mathematics education*, Kluwer Academic Publisher, the Netherlands.

Bose, K., 2008a. Gaps and remedies of early childhood care and education (ECCE) programs of Botswana. *Educational Research and Reviews: Academic Journals* 3(3), 77–82, viewed 5 December 2014, from http://www.academicjournals.org/ERR

Bose, K., 2008b. 'Early childhood care and education programmes in Botswana: Policy (2001) implementation', *Asia-Pacific Journal of Research in Early Childhood Education* 2(1), 3–23.

Bose, K., Tsamaase, M. & Seetso, G., 2013, 'Teaching of science and mathematics in pre-schools of Botswana: The existing practices', *Creative Education* 4(7A1), 43–51, viewed 5 December 2014, from www.scirp.org/journal/PaperInformation.aspx?paperID=34658&

Bose, K. & Seetso, G., 2016, *Science and mathematics through play: A resource book for early childhood education teachers in Botswana*, University of Botswana, Botswana.

Chang, H., Stipek, D. & Garza, N., 2006, *Deepening the dialogue: Key considerations for expanding access to high quality preschool in California,* Stanford University School of Education, Palo Alto, CA.

Christensen, P.H., 2004, 'Children's participation in ethnographic research: Issues of power and representation: Children and society', *The International Journal of Childhood and Children's Services* 18, 165, viewed 21 September 2015, from http://www.academia.edu/14435497/Childrens_participation_in_ethnographic_research_Issues_of_power_and_representation

Clements, D.H., 2001, 'Mathematics in the preschool', *Teaching Children Mathematics 7*, 270–275.

Darling-Hammond, L., 2000, 'How teacher education matters', *Journal of Teacher Education* 51, 166–173. http://dx.doi.org/10.1177/0022487100051003002

DeRoche, K.K. & Lahman, M.K.E., 2008, ,Methodological considerations for conducting qualitative interviews with youth receiving mental health services', *Forum Qualitative Social Research* 9(3). viewed 21 Sepetember 2015, from http://www.qualitative-research.net/index.php/fqs/article/view/1016/2189

Essa, E.L., 2011, *Introduction to early childhood education,* Wardsworth, Belmont.

Flyvbjerg, B., 2006, Five misunderstandings about case-study research, *Qualitative Inquiry* 12(2), 219–245. http://dx.doi.org/10.1177/1077800405284363 viewed 21 Sepetember 2015, from http://qix.sagepub.com hosted at http://online.sagepub.com

Fu, V.R., 2010, *Learning and teaching in preschool,* viewed 12 December 2014, from http://www.pbs.org/teachers/earlychildhood/articles/learning.html

Gallenstein, N.L., 2005, 'Engaging young children in science and mathematics', *Journal of Science Education* 17(2), 27–41. http://dx.doi.org/10.1007/bf03174679

Garbett, D., 2003, 'Science education in early childhood teacher education: Putting forward a case to enhance student teachers' confidence and competence', *Research in Science Education* 33, 467–481. http://dx.doi.org/10.1023/B:RISE.0000005251.20085.62

Gay, L.R., Mills, G.E. & Airasian, P., 2009, *Educational research: Competencies for analysis and applications,* Pearson, London.

Grand Fun Alley Learning Center, 2014, The importance of play, viewed 4 November 2014, from http://www.gfalc.com/#!The-Importance-of-Play/c1pou/1

Hlas, A. & Hildebrandt, S., 2010, 'Demonstrations of pedagogical content knowledge: Spanish liberal Arts and Spanish Education majors' writing', *L2Journal* 2, 1–22.

Hodkinson, P. & Hodkinson, H., 2001, *The strengths and imitations of case study research, a paper presented to the Learning and Skills Development Agency conference on Making an impact on policy and practice,* University of Leeds, UK.

Johansson, E. & Pramling Samuelsson, I., 2006, 'Play and learning- inseparable dimensions in preschool practice', *Early Child Development and Care* 176, 47–65. http://dx.doi.org/10.1080/0300443042000302654

Kagan, S.L. & Lowenstein, A.E., 2004, 'School readiness and children's play: Contemporary oxymoron or compatible option?' in E.F. Zigler, D.G. Singer & S.J. Bishop-Joseph (eds.), *Children's play: The roots of reading,* Zero to three Press, Washington, DC.

Kallery, M. & Psillos, D., 2001, 'Pre-school teachers' content knowledge in science: Understandings of elementary science concepts and of issues raised by children's questions', *International Journal of Early Years Education* 9, 165–177. http://dx.doi.org/10.1080/09669760120086929

Lahman, M.K.E., 2008, Always othered: Ethical research with children. *Journal of Early Childhood Research* 6(3), 281–300, viewed 21 September 2015, from http://ecr.sagepub.com/content/6/3/281.full.pdf

Lehrer, R. & Schauble, L., 2006, *Handbook of child psychology: Scientific thinking and science literacy,* John Wiley & Sons, Inc., USA.

Lind, K.K., 1999, 'Science in early childhood: Developing and acquiring fundamental concepts and skills', *American Association for the Advancement of Science (AAAS),* viewed 12 December 2014, from http://www.project2061.org/publications/earlychild/online/experience/lind.htm

Moomaw, S., 2011, *Teaching mathematics in early childhood,* Brookes Publishing Company, Baltimore.

National Association for the Education of Young Children, 2009, *Developmentally appropriate practice in early childhood programs: Serving children from birth through age* 8, viewed 11 November 2015, from http://www.naeyc.org/files/naeyc/file/positions/position%20statement%20Web.pdf

National Association for the Education of Young Children, 2012, *References to play in NAEYC position statements: Developmentally appropriate practice guidelines*, viewed 11 November 2014, from http://www.naeyc.org/files/naeyc/files/Play%20references%20in%20NAEYC%20position%20statements%2011-12.pdf

Scantlebury, K., 2005, *Maintaining ethical and professional relationships in large qualitative studies: A Quixotic ideal?,* viewed 21 September 2015, from http://www.qualitative-research.net/index.php/fqs/article/view/35/73

Singer, D., Golinkoff, R.M. & Hirsh-Pasek, K. (eds.), 2006, *Play=Learning: How play motivates and enhances children's cognitive and social-emotional Growth,* Oxford University Press, New York.

TESOL International Association, 2015, *Qualitative research: Case study guidelines*, viewed 5 March 2015, from http://www.tesol.org/read-and-publish/journals/tesol-quarterly/tesol-quarterly-research-guidelines/qualitative-research-case-study-guidelines

Yin, R.K., 2003, *Case study research: Design and methods*, 3rd edn., Sage, Thousand Oaks, CA.