Studying the landscape of families and children's emotional engagement in science across cultural contexts

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Abstract

It has been reported that in cross-cultural contexts, Western science content is often not used in everyday practice, and the learning of science is often viewed as difficult and having no social meaning (e.g., Aikenhead & Michell, 2011). It is suggested that the cultural relevance of everyday family practices and Western constructions of science concepts may be worlds apart, requiring new forms of brokering between schools and communities. But this expansive cross-cultural work says very little about everyday family life for supporting the cultural learning of science for the birth to five year period. In this paper we report on how everyday and abstract scientific concepts are meaningfully constructed in the context of culturally relevant life events (Vygotsky, 1987) for the early childhood period. We analyse the science concepts involved in the process of a South Sudan Dinka wedding in Australia, and explore these concepts through science related games with families who in turn introduce the concepts to their children as part of their playgroup activities. The results of the study indicate that finding Dinka words to name Western science concepts was challenging, and conceptualising everyday routines and cultural practices with scientific lenses amplified emotional engagement in science and generated new family discourses between children and their extended families. The study contributes to better understanding the relations between everyday cultural practices and Western science learning in the early childhood period.

Keywords

Emotions; science practices; children; family; concepts; perezhivanie

ISSN 1838-0689 online

www.education.monash.edu.au/irecejournal/

Introduction

There is now a large body of literature that has shown that confidence and competence to teach science has been a longstanding problem in the early childhood and primary years (e.g., Garbett, 2003; Traianou, 2006). Research suggests that this lack of competence and confidence is associated with negative feelings towards science learning, yet this emotional dimension of science education research has had limited attention (Roth, 2008. A great deal of emotional labour is involved in the teaching of science in the early years of school (Zembylas, 2004a), yet this is rarely acknowledged (Zembylas, 2004b). Hadzigeorgiou (2005) argues that, "although feeling and thinking go hand in hand, emphasis on the cognitive dimension of the learning process has resulted in the neglect of emotions, despite the evidence of the importance of the latter" (p. 27). As such, it is timely that a study of the relations between emotions and learning science in everyday family practices for the early childhood period be undertaken. This paper seeks to fill this gap in understandings by presenting a case study of how children and families from the South Sudan Dinka communities living in Australia learned science.

Traditionally, affect has been an important learning domain in early childhood education. However, with the increased attention on developing cognitive outcomes (Brennan, 2014), the importance of the interrelations between emotional development and learning (Vygotsky, 1994) in the early years has been diminished (Brennan, 2014). What the research shows is that there is a trend to separate the child's thought processes from their emotional connections to their everyday lives, resulting in a continued siloing of emotions from learning (Fleer, 2010). Yet we know that the separation of affect and intellect is problematic (Vygotsky, 1934/1986) because how a child comes to know something is influenced by how s/he feels. That is, how a child feels about science will shape how they construct their science learning. Similarly, how an adult feels about being a teacher of science will also influence how he or she will teach science. This matter is particularly emphasised in the cross-cultural literature where the "struggle, wounds, and pain of traversing into dominant worlds" of science have been extensively documented (Aguilar-Veldez et al., 2013). Aikenhead has written extensively about this and in so doing popularised the evocatively metaphoric term "border crossing" to describe the cross-cultural difficulties facing many who are expected to learn science (e.g., Aikenhead, 1996). While a lot is known about border crossing between school learning of science and children's everyday family and community life across cultures, this relation has not been examined for the early childhood period.

There is much in the literature and popular press that discusses the way science is presented in schools (Zapata, 2013), suggesting that students need to be engaged in science learning early and effectively, if they are to continue studying this important area beyond the compulsory years. There is a long-standing and apparently unchanging strong connection between a lack of science content knowledge studied at school and student teachers not feeling confidence to teach science (Garbett, 2003; Howitt, 2007; Lindermann-Matthies et al., 2012). A different way of presenting and teaching science concepts across the age spans is needed if this cycle of reduced confidence and understanding is to be ameliorated, particularly if effective participation in an increasingly scientific world is to occur. Refocusing the research lens on families and how adults bring to life everyday science concepts can provide one way forward for change. The study reported in this paper sought to investigate how extended families from a specific cultural group engage with their children (birth to 5 years) when learning science concepts at home and during playgroup time.

We begin with a brief overview of the literature related to the learning of science concepts, followed by a discussion of the conditions that support the learning of science in culturally diverse

ISSN 1838-0689 online

settings. The study design and findings are presented next. In the context of the theory that guided the research, the analysis and the conclusions drawn are presented.

Culturally-based science practices

There is a vast body of literature that documents children's learning of science concepts, with many studies suggesting that young children construct their own interpretations of the world around them (e.g., Taber, 2015; von Aufschnaiter & Rogge, 2015). This longstanding and very large body of research has demonstrated personal constructions/understandings across a broad range of sciences. For instance, earth science (e.g., Saçkes, Flevares, & Trundle, 2010), space science (e.g., Trundle, Saçkes, Smith, & Miller, 2012) and physical science (e.g., Varelas, Pappas, Kane, & Arsenault, 2008). The literature also gives evidence of the developmental changes in children's explanations of certain science concepts over time (e.g., Tytler & Peterson 2000).

It is clear through many studies that young children have their own constructions of science phenomena that are in a developmental process of becoming more sophisticated. Tytler and Peterson (2000) suggested that children's social life, including the appropriation of cultural tools, such as language expression, plays a crucial role in this developmental process of conceptual change. That is, children's social experiences are meaningful in developing their thinking with scientific concepts. However, other studies go further in expanding on children's social experiences as a way of more authentically capturing the landscape of scientific learning (Aikenhead & Michell, 2011). As such, researchers have begun to pay attention to children's thinking in relation to science concepts in practice, rather than purely understanding children's thinking about science concepts from the outcomes of test-based results (e.g., Tytler & Peterson 2003, 2004).

Research has also demonstrated that it is important to rethink science teaching practices and to make young children's experiences more meaningful. Aikenhead and Michell (2011) show in their extensive review of the literature that canonical science content is not always easily understood. It requires extensive border crossing for it to be meaningful to many learners, particularly to learners from cultural contexts that are significantly different to the culture of Western science. Their expansive work draws attention to the disruptions, tensions, and challenges faced as students come to experience another form of knowledge construction where an unfamiliar system of representation of their world is presented. For instance, they have shown that the process of coming to know is actually a personal, participatory process of gaining wisdom-in-action from significant others. In the context of secondary science learning, Aguilar-Valdez et al. (2013) discuss how educators from dominant cultural backgrounds have difficulties with understanding the perspectives of diverse learners in science classrooms, pointing to the narrowness of how science content knowledge is conceptualised in classrooms. They suggest that the border crossing between Western science concepts and localised Indigenous concepts is often invisible to educators.

A more expansive understanding of knowledge construction has been put forward by Aikenhead and Michell (2011), who argue that Indigenous ways of living in nature best describe the science of Indigenous peoples. The science knowledge and ways of learning about nature must be experienced through place, relationships with nature, people, and an appreciation of how concepts have been formed historically from wisdom-in-action for the purposes of survival. These constructions of knowledge suggest a broader reading of science concepts where people, places and nature are central. In the context of the study reported in this paper, this construction of

ISSN 1838-0689 online

knowledge casts the net wide and suggests a dynamic and moving context for research. This broader construction of knowledge begins to address the silos, noted by Roth (2008) in relation to the dynamics between emotions and learning in science, and speaks more generally about knowledge construction in science as argued by Corrigan (2009). Hadzigeorgiou (2005) argues "if knowledge is indeed a human construction then not only the prior conceptions of the learner… but also his/her fears, anxieties, hopes, and expectations should be considered" (p. 25).

A theoretical framework for studying emotions and science learning

"Good science cannot proceed without a deep emotional investment" and expansive imagination (Fox Keller, 1983, p. 197). In this review of the work of Nobel-Laureate Barbara McClintock, Fox Keller stated that McClintock had an " 'exceedingly strong feeling' for the oneness of things" (p. 201), as she projected herself inside the microscope to "join" the chromosomes she was studying. McClintock's understanding came from both looking down a microscope and also by being in the field studying the corn crops closely. This approach "both promotes and is promoted by her access to the profound connectivity of all biological forms – of the cell, of the organism, of the ecosystem" (p. 201). However, these imaginative playful explorations and wonderings are often ignored (Siry & Kremer, 2011). Carson (1999) highlights the importance of children's feelings about the world, where emotional experience is considered the "fertile soil" in which knowledge and wisdom can grow.

These participatory processes of gaining a "feeling for the organism", and "wisdom-in-action" (Aikenhead & Michell, 2011) are all located and given meaning by specific cultural contexts. It is these cultural-historical contexts that we were interested in investigating, so that insights into the emotional dimensions of learning in science could be studied. To achieve this goal, we have used Vygotsky's concepts of the social situation of development, *perezhivanie*, and everyday and scientific concept formation. Due to constraints of space, it is only possible to present a brief account of the latter two concepts in this article. All these concepts have been drawn from Vygotsky's (1987, 1994, 1997) cultural historical system of concepts, which when taken together, contribute to an explanation of child development.

In our study, culture is conceptualised as that which frames a child's development within a particular community, and refers to the values and practices within that family, community, and the larger society (Hedegaard, Fleer, Bang, & Hviid, 2008). It is the reciprocal relation the child has with his or her (social and material) environment that enables the child to shape and be shaped by the developmental conditions surrounding the child (Vygotsky, 1994).

Specific to this study is the South Sudanese Dinka community now residing in a southern Australian city. Everyday life in Australia for members of this community includes the languages spoken by the community (Dinka, Arabic, and English), the institutions frequented (playgroups, schools, churches) and traditional practices, which are valued and continue to be enacted in Australia. For example, in a special form of wedding, negotiating the number of cows for a bride and transporting the cows from the groom's house to the bride's house in Sudan is still practiced. It is the way "historically formed and valued practices… shape contemporary practice and afford everyday life opportunities for child development" (Fleer, 2015, p. 47).

An important part of child development is the qualitative changes in a child's understanding of science concepts in everyday practice. This begins with everyday life experiences and the child's

ISSN 1838-0689 online

early formation of concepts. Therefore it was important for our study to acknowledge and understand the everyday cultural practices of families and the way these could complement Western ideas of science to enrich everyday life and support later school learning. To achieve this understanding, we drew upon the dialectical relations between everyday and scientific concept formation.

Everyday and scientific concept formation

Everyday and scientific concept formation and *perezhivanie* (Vygotsky, 1987, 1994) were used in this study to conceptualise the way adults and children learn science together. According to Vygotsky (1987) a concept is formed through an evolving, dynamic process "which is a complex…act of thinking that cannot be mastered through simple memorization" (p. 169). Further, Vygotsky argued that the formation of concepts occurs through two spiralling lines of development: initially, children experience real life events where spontaneous concept formation develops. That is, children experience an event and may begin to construct their own theories (Fleer, 2010). This is known as an everyday concept and is an important part of the process of conceptual development. The second line is directed by non-spontaneous concept formation of scientific concepts. These form abstractly and require some form of formal instruction to aid understanding (Vygotsky, 1987). Therefore the development of everyday concepts into abstract scientific understanding requires the participant to have some form of instruction from a more capable individual in a cultural context. In this study, we provided workshops for the adult participants to remind, support, and introduce English words for abstract scientific understandings of science concepts, which were further enhanced by participation in games and activities. These activities highlighted abstract concepts such as force, friction, and resistance during a tug of war game introduced in the context of analysing the forces in everyday life. Further, play episodes were organised for the children (by adult participants) to support the children's everyday understanding of concepts such as push and pull. An intergenerational context of grandparents, mothers, and children learning science together with the teachers and researchers was created and formed the basis and boundary of the data gathering process.

Perezhivanie

Games were introduced to the adult participants for two reasons: first as a means of refreshing and supporting adult understanding of abstract scientific concepts (force, friction, and resistance) in an engaging and enjoyable way, and second, to potentially make visible if and how emotions and concepts evolved and were dynamically related or embedded within each other. We used the concept of *perezhivanie* to analyse the data. The concept of *perezhivanie* is complex, because it is a theoretical proposition, an epistemological argument and a methodological approach (Mok, 2015). *Perezhivanie* is a concept in transition (González Rey, 2014) and therefore needs explanation when used.

Perezhivanie as a theoretical proposition gave our study an important tool for analysis. In our interpretation, Vygotsky argued that personal and situational characteristics must be studied together. They cannot be separated. Vygotsky (1994) noted that *perezhivanie* is "that which is experienced…and how I, myself, am experiencing this" (p. 342), and in this reading the focus is on understanding the unity of *person and person experiencing the environment*. What each child brings will mean that each child experiences the same environment differently because of their own personal characteristics and previous experiences. For instance, when a child finds a worm tucked behind

ISSN 1838-0689 online

leaves and rocks on the ground, how they respond to the worm and how they emotionally relate to it, will be dependent upon what they have previously experienced and understand. Is the worm something of great beauty to be studied closely or is it something to be feared? The concept of *perezhivanie* helps explain how the same environment can be experienced differently. A child who wishes to study the worm will have a different developmental trajectory to a child who is frightened by the worm. This theoretical reading of *perezhivanie* captures both personal and environmental characteristics in unity rather than seeing them in silos, where one may influence the other. This theoretical proposition gives a different foundation for research that we drew upon to frame our study of Dinka families engaged in learning science. The concept of *perezhivanie* was used to better understand how families with different cultural frames of reference, experienced the learning of Western science concepts.

Perezhivanie as an epistemological argument provided a new way of framing and coming to understand the relations between Western science and Dinka constructions of knowledge. Vygotsky (1987) put forward a holistic conceptualisation of human psychology arguing against the behaviouristic view at that time, where human processes were reduced to separate functions. Hedegaard, et al. (2008) has also shown in her approach the importance of a holistic approach, where the richness and complexity of phenomenon are captured together. She argues that in a cultural-historical approach to research the "multi-dimensional elements of children's participation in everyday life" (p. 30) are captured. In order to understand children, we must also understand the institutional practices, the societal values, and the child's personal characteristics together. She argues that the demands and expectations, and how an individual meets these, underpin a dialectical approach to researching children's development, where contradictions, transitions and crises emerge and act as a source of development for children. This holistic conception is the antithesis of a reductionist view of research. As argued by Mok (2015), perezhivanie allows for a more holistic approach, giving rise to a very different epistemological argument than reductionist approaches. In our research this meant we researched holistically the conditions we created in the professional learning program for the extended families. This allowed us to better understand how concepts explored at the interpsychological level among adults and children, were being discussed, named, and potentially conceptualised by children and families at the intrapsychological level. This in turn allowed us to examine new levels or conscious expressions of concepts that became increasing evident, or indeed to note any contractions between Dinka and Western constructions of knowledge that might emerge.

Perezhivanie was an important concept in our methodological approach because this term was also introduced by Vygotsky (1994) as a unit of analysis. Vygotsky (1994), in discussing perezhivanie as a unit of analysis, detailed how the elements of oxygen and hydrogen do not give the essence of what is water. Together the elements do not constitute the phenomenon and substance of water. It is well understood that the human cell, with all of its genetic matter, gives the essence of what it means to be human and specifically the characteristics of that particular human from which the cell is drawn. That is, the biological essence of a human being can be determined by just one cell. Vygotsky argued that the task of research is to determine what is the essence or unit that makes up the whole. What are the interrelational characteristics that together become the smallest unit that represents the complex whole? Simply put, what is the unit that represents the whole?

It has been argued that *perezhivanie* represents the whole of the child's personal characteristics and how they are experiencing and contributing to the situational characteristics of the environment. *Perezhivanie* as a *unit* of analysis avoids reducing a child to disconnected components of personal

ISSN 1838-0689 online

characteristics or environmental characteristics in the process of analysis. *Perezhivanie* "allows more adequate theorization about how the individual and the environment are represented as a complex, dynamic, and rich unity in human mental development" (Mok, 2015, p. 151). In our study, *perezhivanie* has been used in all its complexity as a unit of analysis to explore the emotions that are integral to science learning, and also to examine the emotions that are part of the scientific interactions between adults and children. In the present study, the concept of *perezhivanie* as a unit of analysis allowed for a fine-grained microgenetic analysis of tensions, contradictions, and transitions, as Dinka families engaged in playful activities in professional learning and later teaching their children science concepts in everyday life at home and during playgroup time.

Study Design

The main interest of this study is the way *perezhivanie* as a unit of analysis (Brennan, 2014), is integral to a positive and collective (researchers, adults, and child participants) science learning experience. *Perezhivanie* captures the essence of the scientific interactions between adults and with children as they participate in playful activities and games while learning about science concepts related to culturally relevant events in the Dinka community.

The specific research question that drove the study was: what is the emotional nature of scientific learning in the Dinka community across the playgroup contexts of family homes, the community centre and during workshops?

This study took place in an inner city playgroup in a large, southern Australian city. Video observations were gathered in a playgroup setting situated in a school hall, the homes of participants, and a community centre in close proximity to the homes and playgroup used for the workshops where adult participants and researchers worked collaboratively on ways to share science thinking and learning.

Participants

Participants in this study consisted of a small community of recently arrived South Sudanese Dinka families who attended a playgroup sponsored by a philanthropic organisation. The playgroup supports established and recently arrived refugees. There were 22 adult participants consisting of grandmothers, carers, parents, and educators. An educator, H, guided the playgroup, with the support of G, the Dinka community leader, and educator K from the organisation that funded the program. In addition, there were 34 children (median age of 3.7 and age range between 0.5 - 5.1 years). All participants attended the community playgroup.

Data collection

Video observations of participants were collected over a three-week period. Interactions were recorded using two cameras, and occasionally three. In the playgroup there was always one fixed camera to take in the whole room and another hand-held by a researcher who filmed families and teachers as they participated in activities. The third camera was also hand-held, and filmed children as they participated in activities outside. In the home, two cameras were used, both hand-held. During workshops, one camera was fixed and another was hand-held. A total of 42 hours of video data were gathered.

ISSN 1838-0689 online

Interviews: As part of the study, informal interviews of educator H and the Dinka community leader G were undertaken during the playgroup sessions so that a more holistic understanding of the teaching-learning context being created could be ascertained. Specifically, the culturally relevant practices and suggested idea of science concepts connected to a traditional Dinka wedding was draw out during each observation period. These informal interviews were completed in situ and some were scheduled prior to or after the workshops and playgroup sessions.

Data Analysis

Data analysis was completed through the three-stage approach proposed by Hedegaard and Fleer (2008). The initial stage began with *common sense interpretation* across the whole data set, where participant's *emotional engagement* when involved in science learning was noted. These were tagged and video clips of relevant data duplicated. An important aspect of using *perezhivanie* as the unit of analysis at this stage was noting the individual's social situation of development and the way each participant experienced the games used to foster science learning differently, individually and collectively (Vygotsky, 1994). These video segments were further tagged when participants were remembering and showed some form of emotion, such as when discussing the rules of a game and participating in the actual game (in these instances it was usually happiness or joy as highlighted by laughter). These video segments were used in the next stage of analysis.

The second stage was *situated interpretation* where research across different sites was collated (home, playgroup, community). During this stage links were sought across sites, for example, if a game that researchers introduced in the workshop was repeated with children during the playgroup, or if the adult or child participant initiated a conversation about science. During this analysis, individual and collective emotions were analysed. This included paying careful attention to body positioning, physical contact, and non-verbal cues, including eye directions, facial expressions, and utterances (Adams & March, 2014). As noted by Brennan (2014) this is a challenging endeavour as much emotion occurs internally. Adding further complexity was the partial use of the Dinka language by participants, so unless the translator was present, the data was not usable. If the participants showed some form of obvious emotion (happiness, engagement) in related vignettes, the clips were collected together for further analysis.

The final stage completed was *thematic interpretation*, where meaningful patterns in line with the research aims were utilised to formulate new understandings and conceptual relations of science learning where participant's *perezhivanie* was noted. All of the vignettes were re-analyzed in relation to generalisations and everyday and scientific concepts.

Findings

The findings indicate that the contradictions between Dinka and scientific language provided a rich and dynamic zone in which playful activities could be introduced. Play helped realise a collective (Hudson & Kidman, 2008) engagement in science concepts where emotional moments amplified everyday contexts and concepts for individually and collectively (Vygotsky, 1994) learning science, where scientific terms for everyday practices did not exist in the Dinka language. Two central ideas have come from this study. They were:

1. Contexts and concepts for realising shared scientific language
2. Collectively experiencing positive emotional moments to amplify learning

ISSN 1838-0689 online

Contexts and concepts for realising shared scientific language

A key finding of the study was the realisation by families, teachers, and researchers that some scientific terms did not exist in Dinka language. For example, in the following interview with educators (H, K) and the Dinka family leader (G), this problem of effectively engaging with science concepts was identified:

H: We talked yesterday, at the end of the session, language and some words don't exist but are new for children and parents. Some of the words that belong to science. G you said yesterday.
G: Push and pull is ok
H: Words like gravity and motion we don't know with Dinka. Maybe there is some Dinka come from country they know but we are born in the city and we don't know maybe some others born in the village they know in Dinka.
K: Rocket to moon – do you know that story. They found on the moon people can float around
G: We have something in the middle not go down and not go up – when you put something not heavy in the water and it not go down.
H: It is hard for kids to understand this
K: It's hard to understand
G: It is good for us but for the younger one it is hard
K: How can we best explain some science ideas to the parents so they can explain it best to the children?
K: People are learning something new, new words

Noting that "*some of the words*" that were being discussed "*belong to science*" and not to the Dinka language is an important realisation in any cross-cultural context where the naming of concepts has to be viewed as part of a system of scientific thought with its own language and theoretical framing. The Dinka language represents concepts in action for their specific communities (both in Sudan and in Australia) where everyday practices are introduced to children through the lens of the Dinka language. Vygotsky (1987) argued that concepts are developed as word meanings. Concepts are always dynamic because they capture and name aspects of everyday life, which help children understand their everyday world and to collectively share meaning within families. But the *family curriculum* is likely to be different to the *curriculum of science*. Corrigan (2009), in reviewing the literature on informal and formal learning of chemistry, notes that a curriculum that "requires a broad contextual understanding of chemistry or science also recognises the importance of both the formal (i.e., in the classroom learning) and informal, (e.g., via the mass media) procedures students adopt in their learning" (p. 351). The everyday practices of families shape and are shaped by routines, rituals, and traditions, where words capture concepts in action through these daily practices. How they are named is linked to culture, and in the Dinka community some of these practices were found to not have an equivalent single word or set of words to name the scientific concepts in use.

Corrigan (2009) draws attention to practices described as informal, as voluntary, unplanned, learner led, outside of formal settings, to have more unintended outcomes, to be social, open-ended, not assessed, and undirected. She also notes these often have low currency in the broader community. By contrast, formal settings are framed in relation to specific legislated outcomes, such as science concepts, which are planned, structured, compulsory, assessed, credentialed in some way, more closed in nature, and interestingly, hold more currency—that is, to be more highly valued in the broader community. She argues against binary structures and suggests that there should be a relation between informal and informal learning if authentic learning is to be achieved. In line with this, Vygotsky (1987) argued that the challenge was in relation to how children develop scientific or abstracted understanding (i.e., concepts) from their spontaneously acquired everyday concepts learned through practice. It was the relations between everyday and scientific concept formation that formed the basis of his theoretical work when coming to understand how children develop higher mental functions.

Vygotsky (1987) noted that key to conceptual development was generality and systematicity: both abstractions that he described as being beyond the preschool period. However, in the other volumes of his collected works he theorises the two lines of development (biological and cultural) supporting the argument that the conditions for cultural development can extend the biological or natural development of the child. As has been noted in the broader literature, the hierarchically organised systems or categories that make up everyday life, such as taxonomies, are introduced to children early. For example, a child comes to understand that the term “dog” has a superordinate, such as “animal”. Children learn about the superordinate term “family” through coming to know the categories of “mother”, “father”, “grandmother”, through everyday lived experiences, and the naming of categories by family members.

Nelson (1995) argued that:

> superordinate categories do not exist as such in the real world, but only in the language used to talk about them, the child cannot have a prelinguistic concept that is the equivalent of the adult superordinate concept. The child’s problem then is to find a way to form word meanings for superordinate classes that map the adult meaning system appropriately (p. 233).

What is known is that adults and children share a language system that is essentially a conceptualisation process. Children acquire words to name what is in their everyday context, and these words form the basis of their conceptualisation of their world. Vygotsky (1987) noted that the names of objects overlap with the references attributed to them by the child’s family. That is, adults use the same words to talk about the same things. This constitutes a shared world even though understanding of what is being shared may vary between that of the adult and the child. Nelson (2015) has argued that: “it should be noted that even at this early point the child’s conceptualizations, albeit they are individually constructed, are of the cultural world – its artifacts, its social relations, as well as the natural kinds that inhabit it” (p. 233). Thus, engaging with families, to introduce scientific language into everyday practices during children’s experience of being at playgroup, matters. But where these terms do not exist in the Dinka language suggests that a broader conceptual framing for science is needed. Further, this *worldview elaboration* can only be achieved when there is a recognition that everyday practices do not always include specific scientific language, for example, gravity when discussing the content of a storybook that featured astronauts flying a rocket into space. Finding the ways for a *worldview elaboration* rather than a *border crossing* becomes increasingly important. The latter suggests a dichotomous relation whilst the former is a more holistic conception that scholars following the work of Aikenhead have also sought to present when using the term border crossing (Aikenhead & Mitchell, 2011). Worldview elaborations help to conceptualise the relations between home languages and practices, and science learning in early childhood settings. However, this concept did not capture the emotional dimensions of learning and experiencing science. A discussion of this now follows.

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Collectively experiencing positive emotional moments to amplify learning

During an interview, the community leader G and educator H decided that a Dinka wedding would provide opportunities for science concepts to be introduced to the participants. The community leader G explained that the groom's family approaches the bride's family and negotiates the number of cows to swap for the bride. After extended negotiations, an agreement on the number of cows is reached; the groom's family walks the cows to the bride's parent's house (this may be a journey of several hundred kilometres). The community leader G explained that pushing and pulling were used to move cows as some cows become tired and need to be coerced into moving. From this exchange, it was decided that a tug of war would be a way to introduce the abstract concepts of force, resistance, and friction to the adult participants during the workshop along with formal instruction by the research leader S.

S: Can that be a long journey sometimes or do they usually live nearby?
G: Sometime long like from here to Sydney
H: To move the cows, the 200 cows
G: Yeah they walk if night time come[s] they will sleep anywhere there and tomorrow morning come they will start anywhere there. Sometime there is other cow if they are tired they don't want to move. We will haul it, we will lift it up and some people will go with the other cow and some people will live with the cow the one that is tired. We try to push it little bit until it will be strong to walk again.

The researchers collaborated with G, a respected Dinka community member. The Dinka cultural context was an important aspect to take into consideration when collaborating on the type of activities to refresh and support parents understanding of everyday and scientific concepts and to introduce the terms of force, friction, and resistance in English.

Context of the Workshop

In the workshop sessions, eight adults were seated in a semi circle and researcher S explained the abstract science concepts behind the tug of war game such as force and resistance, and the interrelated everyday concepts of pushing and pulling. A second researcher, M, elaborated on the importance of explaining this to children and suggested that children need to be encouraged to develop their own theories (Fleer, 2010). S explained the tug of war game and the relation this had to Dinka weddings, followed by an explanation of the various forces of resistance and friction. G then translated (in Dinka) for the community. As G was talking, she stood and positioned herself with a wide stance and held her hands as if she was holding an imaginary rope, imitating the movements needed for the tug of war game, moving her whole body forward and backwards. This also gave the possibility to experience and discuss the idea of equal forces acting to keep something stationary.

Data context

There were four participants positioned on one side of the rope and two participants on the other, interspersed with a researcher and educator. Although not dressed for the occasion, the participants participated in the tug of war with vigour. It is inferred from the changing facial expressions that the participants were initially concentrating on what was being relayed by the researcher (Figure 1). Quite quickly after the tension was taken up in the rope and pulling began, it is suggested the participants showed signs of enjoyment as they were smiling and laughing while

ISSN 1838-0689 online

completing the activity, with instructions being relayed by others who were not participating. As one side was pulled fully over the line positioned in the middle, sustained, loud laughter, shrieks and clapping was heard, which was followed by congratulations and congratulatory palm touching between participants.

S: And how about the [playgroup] session last week?
G: It was good we tried last week Tuesday playing the game with the kids (smiling, laughing, shaking head left to right gently)
H: We did, we did (laughing, G continues to smile)
S: What did you try and do?
H: We had a tug of war
S: Wish we were there
H: Oh it was, it was so much fun (laughing and making eye contact with G both nodding)
M: Was it the grown ups against the kids?
G: Yes, yes (laughing and continues to smile)
H: The children barely got a look in. The children were very keen (more laughter, smiling)
H: Look I must say that I was really excited that the information went to the adults first because last Tuesday they seemed to be really switched on to sharing some of that activity level with the children. …maybe what we can think about for our …adult focus each week is something along the lines of learning through play but learning important things like these science concepts so that it like builds a bridge between what you might know instinctively or tap into the limitations – I am talking about myself here the limitations of my knowledge and understanding of force or power or what ever.
S: Yes it is hard science
H: Yeah it is. It is really hard science
S: and we don't think about that in our everyday lives
H: …No that's right and if there is a way to share that with adults, it may do something to trigger some passion about learning that they have as individuals as well as wanting to share that with their children

In this study, we see the collective nature of emotions (Vygotsky, 1994) where working together for a common goal brought out the emotion of engagement and all of the participants were concentrating on working together to pull the other team over the line first. In addition, when the game had finished, collective laughter, smiling, and congratulatory hand touches became a way to continue the close physical social interaction. Hudson and Kidman (2008) highlighted that interactivity with real life situations supports science learning. In addition, Hudson and Kidman (2008) found that for students, working in a group was a powerful way for science learning to be remembered.

In the game of tug of war, the participants' outward signs of smiles and laughter indicated that they were individually experiencing positive emotional moments in a collective situation of enjoyment and engagement with the activity. However, according to Wilson (1999), laughing can be a type of mask which does not always reflect the true emotion being experienced. Vygotsky (1999) argues that laughing can be a type of psychological occurrence, which is voluntarily controlled and forms a conscious emotional experience. In the game "tug of war", although linked abstractly to the culture of the Dinka people (from a Western conception), from these purely outward signs it is challenging to know how the participants felt about the situation (Wilson, 1999). Even so, we

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argue that the participants were engaged and enjoying the experience as the laughter was sustained and the positive emotion seemed to build from the collective. As noted by Kozintsev (2012):

> Laughter marks the boundary of a cultural role; however not the sort of boundary where one serious role is replaced by another, but the sort beyond which there is a breakdown…into chaos (p. 128)

Researchers consciously structured a playful situation taking participants to the boundary of their cultural role, where collective engagement in a joyful, laughter-filled experience coupled with the introduction of abstract scientific concepts through games were experienced. Veresov (2013) highlights dramatic collisions, the laughter being a possible positive form of a dramatic collision (which Kozintsev, 2012 likens to chaos) that potentially results in qualitative changes in the individual. Veresov (2013) writes:

> According to the general genetic law of cultural development, every higher mental function appears twice – first in appears as social relations in a form of emotionally experienced dramatical collision (category) and then within an individual as emotionally experienced internal dramatic collision (p. 10).

Through the collective nature of the tug of war and the general discussions surrounding "push and pull", as constituting aspects of the concept of force, the families and later the children explored the concept of force in a playful way. Experiencing push and pull through the tug of war as a collective group enabled families to viscerally explore force with a level of conscious understanding where the scientific term was introduced. The researchers made explicit the science concept of force with the adults during the playful scientific activities, commenting that young children learn through social interaction and playful events with more capable others (Vygotsky, 1987). The researchers were consciously supporting the adult participants engagement with everyday concepts in the context of scientific knowledge through introducing the abstract English terms of force, friction, and resistance in the context of culturally relevant practice of moving cows over long distances. The interactions were a relation between the families' everyday cultural practices and the introduced Western concept of force. In these moments of drama, developments in understanding become possible, as researchers and participants engage in dialogue that is emotionally charged and meaningfully experienced.

The tug of war was introduced with the aim of providing support for the adults to introduce everyday science concept formation where enactments of similar culturally playful episodes were encouraged and undertaken the following week in the playgroup setting with the children. This potentially changes the relation between adult and child (Marjanovic-Shane, 2010), where the adults consciously take on the role of more capable other during playful events. Further, not only are the adults' roles changed in the emotional experiencing of playful activities and games, but Marjanovic-Shane (2010) argues that laughter in play may change relationships as it occurs concurrently in collective engagement through a physical act (of laughing) and includes usually laughing at the self. "By inviting one to laugh together, one includes others into a close, almost conspiratorial relationship in which a special bond of joint trust and understanding between the players is forged" (Marjanovic-Shane, 2010, p. 52).

In role-play situations, there are many emotions used, such as "confusion, agitation, shame, fear" and tranquility, ecstasy, happiness, which mirror "real-life situations" (Kozintsev, 2012, p. 128). These emotional experiences can be included in playful events that can support the use of laughter

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as a conscious act (Vygotsky, 1966). Laughter is described and related to emotional experiencing, in varying roles, such as "ritual, social, nervous or hysterical" (Kozintsev, 2012, p. 128). In play or real life, there is always a sense of vulnerability or helplessness verging on confusion (Kozintsev, 2012). It is through experiencing the enactment of these emotions in play that children begin to regulate their own emotions in everyday life (Chen & Fleer, in press). It was found that play, as described in this paper, supported the adults' engagement in science, and in turn created new conditions for children's learning and development (Trawick-Smith, 2012).

It is argued that a positive emotive pedagogical system developed between the researchers, the adult participants and the children, where everyday and scientific concepts are brought together through play create a positive science learning experience. This relation is depicted in the model below (Figure 1).

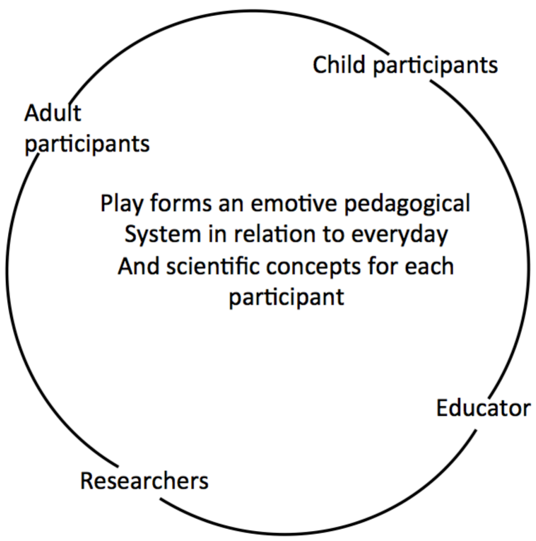

Figure 1: Foregrounding collective emotional engagement in science

Hadzigeorgiou (2005) has suggested that "ideas have an emotional significance which is more important than the application of the concept itself" (p. 27). The emotional significance associated with science learning was a key result noted in this study. During interviews, the educator H commented positively that using playful activities as a learning experience, made her feel "excited" and the parents "seemed to be really switched onto sharing some of that activity with the children". Up until the introduction of playful activities by the researchers, it was observed by H that the parents tended to be less engaged with their children during playgroup and tended to encouraged their children to play with other children only. The introduction of games changed the adults' and, as reported by H, the potential for the adults to learn "important things through play, [which] may build a bridge between what you know instinctively or tap into the limitations" could be achieved. Thus not only was there a change in how the adults interacted with their children as a result of the adults participating in games, there was a conscious awareness in the educator that play acted as a powerful pedagogical tool for adults to support engagement with children's science learning. Learning was no longer conceptualised as an individual activity, but now rather a collective engagement. Pramling Samuelsson and Asplund Carlsson (2008) note that play and learning are interwoven in early childhood. We take this further and argue that adults experiencing learning

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through playful events can be used as a tool to support these adults engaging with abstract scientific concepts which in turn can sustain engagement with their children's learning of science.

Concluding remarks

Longstanding research in science education, with its focus on conceptual change, has often foregrounded the cognitive dimensions of learning only, thus giving a narrow reading of what it means to be a learner (Hadzigeorgiou, 2005). This study has shown how emotionally framed scientific learning can create new conditions for amplifying the learning of science. It is through a *worldview elaboration* that Dinka culture was used as the narrative to playfully experience and discuss the concept of force. Hadzigeorgiou (2005) in citing Feynman shows how science can give new lenses to people when engaging with their everyday experiences, and in the case example in this study, it was about herding cows. Feynman noted:

> The world looks so different after learning science. For example, trees made of air, primarily. When they are burned, they go back to air, and in the flaming heat is released the flaming heat of the sun which was bound in to convert the air into tree, and in the ash is the small remnant of the part which did not come from air, that came from the solid earth, instead. These are beautiful things, and the content of science is wonderfully full of them. These are very inspiring, and they can be used to inspire others. (Feynman, 1969, p. 320).

The families in this study broadened their worldview to include science concepts, giving them not only new lenses to see their everyday world, but also new terms to name the scientific reading that resulted from their participation in the activities and games collectively constructed between researchers, educators and families. Broadening thinking about everyday cultural practices, and exploring how science concepts were named in Dinka, led to many dramatic moments that were emotionally charged for the families and the educators. When all the participants came together (researchers, adult participants, educators, and children) they sought to engage with culturally relevant science concepts through forming a playful pedagogical system that positively explored these science concepts in ways that were relevant to Dinka culture. The games captured the emotional moments in herding cows, whilst also foregrounding the push and pull of tired cows in the context of science.

Play is a powerful tool when utilised in relation to informing adults, educators, and children about science concepts. Play and emotion are intricately related, and it is through the use of *perezhivanie* as a unit of analysis that the individual and collective experiencing of laughter and further positive emotions were found. Although Wilson (1999) and Brennan (2014) argue that it is difficult to gauge the real emotion adults are representing, as laughter can be a "mask" for other emotions (Wilson, 1999) and memories are different to reality when discussing emotion (Brennan, 2014). But as argued by Vygotsky (1999) laughter can help form a conscious emotional experience. *Perezhivanie* represents a dynamic and subjective lens where the meaning of laughter during play was conceptualised.

Although this is a small study, the use of play foregrounded emotions in culturally relevant ways that families responded to positively. Emotions appeared to amplify scientific learning and drew families towards science, even though they initially found the concepts difficult. The findings of this study suggest that the identification of culturally relevant contexts for realising shared scientific language is important, and that experiencing positive emotional moments collectively, can amplify science learning. Adult play appeared to be a key pedagogical characteristic for realising these key

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outcomes for the playgroup families. It is suggested that working closely with families in culturally diverse contexts is key to identifying how scientific knowledge is constructed and enacted, and that role-playing with families could support the learning of science for not just the adults, but also the children. Playgroups is an under-researched but potentially important context for introducing science learning to families, and therefore worthy of more attention.

In our study *perezhivanie* has been used in all its complexity as a unit of analysis to explore the emotions that are integral to science learning, and also to examine the emotions that are part of the scientific interactions between adults and children. The concept of *perezhivanie* was not only fruitful for foregrounding the emotional nature of science learning in families but also productive for realising the disjunction between family practices and Western scientific language. However, more research is still needed if we are to fully understand the relations between emotions and thinking in science across a broader range of cultures.

Acknowledgement

The research reported here was supported by Australian Research Council Discovery Grant DP130101438 (CIs Fleer & Gunstone)

ISSN 1838-0689 online

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