

The Mathematics of Indigenous Card Games: Implications for Mathematics Teaching and Learning

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Many rural Indigenous students perform poorly in mathematics as measured by standard tests. This paper discusses contextualisation of mathematics with respect to Indigenous culture and explores the card games the children play out of school. It was found that some of the games were sophisticated and mathematical in terms of strategies needed to succeed. The paper provides descriptions and mathematical analyses of two games which could be used to develop assessment tools to explore the mathematical understanding of Indigenous students and motivating learning activities consistent with existing community mathematics contexts. It draws implications for the use of these games as contextualisation.

Worldwide, there has been a strong emphasis on the importance of developing a numerate populace who can cope effectively with the practical mathematical demands of everyday life at school and at home, in paid work, and for participation in community and civic life (Australian Association of Mathematics Teachers, 1997). However, some Australian communities fall far short in facilitating the achievement of quality educational outcomes including mathematics outcomes for its students. For example only about 25% of Year 12 Indigenous students in Queensland were eligible for an OP (Tertiary Entrance Score) with a little over 40% of Indigenous students making the transition from primary to secondary state schools and less than half of these still enrolled in Year 12 (Queensland Government, Department of the Premier and Cabinet, 2002). Information provided through Basic Skills Tests and other mechanisms show marked differences between non-Aboriginal and Aboriginal students (Department of Education, Training and Youth Affairs (DETYA), 2000). On average there is at least two years difference even at the Year 3 level, even with some Indigenous students performing at very high levels (Queensland Studies Authority, 2003).

Contextualisation

Numerous variables impact upon these outcomes including isolation, language and cultural barriers, health and wellbeing, socio-economic circumstances, racism and prejudice and finally employment opportunities (Queensland School Curriculum Council, 2001). However this study focuses on the small but important aspect of community mathematics or ethnomathematics.

Most Australian curriculum documents reflect the investigative approach to teaching mathematics (Norton, McRobbie & Cooper, 2002). Curriculum documents that are essentially investigative reflect theories of learning consistent with major elements of social constructivist theory. That is, they acknowledge the importance of students actively constructing their own knowledge from the environment through interaction with physical reality (Luckin, 1999) and through social interaction with peers and teachers (Cobb, Yackel & Wood, 1992; Vygotsky, 1987). The role of the teacher is to facilitate learning by helping students to move through their Zone of Proximal Development (ZPD) and to make the transition from being unable to complete a task to being able to do so (Luckin, 1999). Critical in the process is to know the students' starting knowledge. That is to understand what mathematical thinking they are capable of and to build upon this. Thus it is necessary

to know the mathematical landscape in which the children are immersed, that is the nature of community mathematics that the children are exposed to and have been exposed to.

The interest in Indigenous mathematics cultures has historically seen limited recognition. Until relatively recently the dominant assumption in relation to the Indigenous cultures of Australia was that both the peoples and their cultures would become assimilated into mainstream Anglo Saxon culture (McGreggor, 1999). Under the sway of this assumption little effort was made to account for cultural differences in mathematics education. However, recent policy has been to recognise and value the distinct cultural differences between Indigenous and non-Indigenous Australian cultures and to take account of these in educational processes (DETYA, 2000). Such concern reflects the emerging ethnomathematics school of thought that “the accumulated experiences of the individual and one’s ancestors are responsible for enlarging natural reality through the incorporation of mindfacts [ideas, particularly mathematics facts]” (D’Ambrosio, 1997, p. 16). Mathematics is essentially abstract thinking and a result of an elaboration of an imaginary reality of “myths, codes, symbols and culture in general” (p. 16).

As argued by Matthews (2003), there is a systemic issue at the basis of Indigenous students’ poor educational outcomes. By reflecting dominant society’s views particularly with respect to progress and technology, education systems have devalued Indigenous culture and marginalised it as primitive, simplistic and insignificant with respect to mathematics education (Bourke, Rigby & Burden, 2000; Matthews S, Howard & Perry, 2003; Sara, 2003) leading Indigenous people to believe that “they must become ‘white’ to succeed” (Matthews C, 2003).

Attempts to overcome this issue have given rise to *contextualisation* (Cronin, Sara & Yelland , 2002; Jones, Kershaw, & Sparrow, 1996; NSW Board of Studies, 2000). According to Matthews (2003):

The ‘contextualisation’ of mathematics is a relatively new strategy aimed at bringing relevance into mathematics education for Indigenous students. ... Fundamentally, it involves incorporating aspects of Indigenous culture and Indigenous perspectives into the pedagogical approaches to mathematics education and, in turn, instills a strong sense of pride in the students’ Indigenous identity and culture. ... Essentially, the contextualisation process attempts to develop links between the two knowledge systems [Western and Indigenous] that on the surface seem light years apart. (p. 2)

Clearly then, the teaching of Indigenous students needs to not only take account of Indigenous culture but also to support the manifestation of this culture in education since, as Day (1996) noted, successful educational performance is closely linked to a healthy sense of Indigenous identity. In addition, the importance of student background, personal interests, previous experiences, value placed on learning and value placed on mathematics has been documented in curriculum documents for a long time (e.g., Department of Education, Queensland, 1986) and more recently (e.g., Kemp, 2001, cited in Howard & Perry, 2001).

Thus, contextualisation is a pressing reason to study the cultural mathematics in which Indigenous children are immersed. Such study can establish starting points to enable teachers to link learning activities to Indigenous identities.

Focus of This Paper

In Indigenous communities, the possibilities for cultural mathematics include use of money, sport and gambling. This paper explores the mathematical nature of two probability card games played by Indigenous children and explores the potential of these games to foster mathematical understandings.

Peard (1994, p. 257) reported that “gambling is widespread within Australian culture and is an important aspect of everyday life for a large segment of the Australian population.” Thus the authors had no reason to assume the Indigenous community understudy would be an exception. The place of probability in the curriculum is well documented and found in assessment items from the early years (e.g., ACER Progressive achievement test in mathematics -PATMaths- 2A). Peard, (1994, p. 6) noted of gambling activities that:

Many of the activities involved in gambling are inherently mathematical in nature. These include the calculation of expected returns and winnings at various odds, comparing odds, relating odds and probabilities, and calculating numbers of combinations.

It is clear that there are at least two distinct aspects of gambling, probability aspects and numeracy aspects. A number of authors (e.g., Chick & Hunt, 2001; Howard & Perry, 2001) have noted that both students and adults often poorly understand concepts associated with probability. The use of probability-based games such as card gambling to develop children’s numeracy skills has received very little press. Howard and Perry (2001) have cited as crucial elements in the pedagogy needed to enhance Indigenous learning of mathematics; issues of language, “teacher-student relationships, the learning context and specific pedagogical aspects including fun, teacher consistency and the relevance of mathematical experiences” (p. 304). Card games have a potential to contribute to the enhancement of these elements (Peard, 1994).

Mathematical Impact of Card Games

The games in this paper were described to the authors by members of an Indigenous community located in rural Queensland. There are six games, two of which, with strong potential for mathematics teaching, are described in detail.

Context and Games

The Indigenous community was a town supported principally by welfare and with few employment opportunities. There was a limited number of non-Indigenous peoples who staffed government services (e.g., schools, hospital, police station, post office) and operated two retail outlets. The town was typical of those described by Queensland Government Department of the Premier and Cabinet (2002). Most of the problems described in that report including alcohol and substance abuse, law issues including family violence, and low life expectancy. A significant proportion of the community’s population was transient and there is a history of destroyed traditional way of life and discrimination and exclusion. The community contained two schools, one primary and the other secondary. From an educational perspective, the variables described by Queensland School Curriculum Council (2001) applied; isolation, language and cultural barriers, poor health, low socio-economic circumstances, racism and restricted in future possibilities were evident as serious factors limiting student participation and success.

The limited facilities in the community meant that the three major recreational pursuits that school aged children engaged in were sport (e.g., touch football, rugby league or netball), riding, walking or “hanging around” in groups, and playing gambling games. Community elders confirmed that the incidence of community card games had increased markedly in the community at large and among students in particular since the closure of the canteen some two years ago. One elder explained “There is more money remaining in the community since it is not being spent on drink.” Discussions with indigenous students

and Indigenous teacher aides revealed six gambling games known to students of the two schools. All but the first involved cards.

The first game was based on physical skill and mainly played by boys; the players stood backwards a set distance from a small diameter hole dug in the ground and spun coins through their legs in attempts to get them into the hole. The first player to succeed in spinning a coin into the hole won all the money from the previous failed attempts. There is little mathematics associated with playing this game, but some in calculating winnings.

The second, third and fourth games were based on card games also played in the wider non-Indigenous community. The second game was a simple game based on cutting the cards; the higher card won. The mathematics behind the game is number recognition and order and it may be useful as an aid for teaching numbers to 10 in the early years. The third game was a form of Coo'n'Can or Gin Rummy. It involved accumulating at least 3 cards that form a straight (e.g., 9, 10 and Jack) or were of "one kind" (9 of hearts, 9 of diamonds and 9 of spades). Players could also continue or complete other players' straights or "one kinds". If they could not play cards towards straights or "one kinds", players had to select a card from the pack and discard one card. This discarded card could be picked up by the next player to make a straight or a "one kind". When one player had expended all his/her cards, all other players scored the cards left in their hands – 11 for an Ace, 10 for a Jack, Queens, King and face value for the other cards. For example, a Queen, a 9, two 5s and a 4 score $10+9+5+5+4=33$. Across a series of games, the winner was the player with the least points. This game reinforced number recognition and order, strategy, addition facts and the numeration skill of adding 10, with the major mathematics being in scoring. The fourth game was a form of Switch and the commercial game "Uno". Players had to follow the suit of the starting player or change the suit by playing the same card of a different suit or miss a turn and take another card from the deck. An 8 reversed the direction of play, a 9 made the next player miss a turn, an Ace allowed the suit to be changed and a 2 or a 3 had to be matched with a 2 or 3 or that number of cards had to be taken from the deck. The first player to play all their cards won. Other than reinforcing number recognition and low level counting, this game developed thinking strategies.

Unlike these previous games, the fifth and sixth games, called here RB and DY, appeared to be unique to Indigenous communities. Because of this uniqueness, their complexity, and their potential to assist in mathematics assessment and learning, they are analysed in more detail in the next section.

Mathematical Analysis

RB was the card game that Indigenous aides and students said was most commonly played by students. To start this game, players put out money into two equal piles, one as a pot and the other as a jackpot. The dealer deals two hands to himself, then one to each person until the cards are out. Somewhere through the deal, one card is taken and put aside upside down and covered with a dollar. The dealer makes his decision on what hand to play based on the bottom card (he stacks the two hands before looking under them so that only the bottom card is visible to him). The hand discarded is put aside. The player on the left of the dealer chooses the smallest black or red card (must be the smallest) in his hand and plays it. Anyone else with the next card up must play it, following suit, putting the cards out in order (Ace counts as 1). Sooner or later, the sequence will stop, either when a king is reached or when the next card in the suit sequence is not available (in the discarded hand). The person who played the last card in a sequence then starts another sequence run

in the opposite colour to the suit sequence just finished. This process switching colours and suit sequences continues until someone runs out of cards.

The money is won as follows. The pot is won by the player who runs out of cards first. The jackpot is won by the player who played the card of the same suit that preceded the single card that had been placed under the dollar. However, if this card is an Ace or a card not yet played, the jackpot is added to the next game.

Success in the game requires being able to maximise the number of own plays, while reducing others' plays. Ways to do this are to always to be able to follow any suit or to have cards that end a sequence. Thus, the following cards are good to have in a hand:

- a similar number of black and red cards (so can follow switches);
- sequences of cards so that can play without others joining in;
- high cards, particularly kings, so that more likely to end a sequence and so allow a new sequence to be started; and
- cards that are just below the starting card of a previously played suit sequence, so that more likely (again) to end a sequence.

Low cards are interesting. They could become "just below" cards, but they are unlikely to end a sequence and, if too low, they may never be able to be played.

Consideration of these factors influences what hand a dealer would be likely to choose at the beginning of the game, in that higher cards (definitely) and lower cards (maybe) may be better than middle cards.

Much of what happens in a game is based on luck in terms of cards received, but skill can make a difference in this game, particularly with respect to cards just under previously played sequences. To maximise this option, players must be able to *remember what cards have been played*. Cards can be seen, but cards played subsequently obscure the cards and the game is played so quickly there is no time to check back on what has been previously played. By remembering what has been played, players may be able to work out what is in the discarded hand. Thus, memory plays an important part of the game and over time the person with a good memory has increased chances of winning. Therefore, the game has two sides to it - a game of skill, memory and strategy for the pot and a game of luck for the jackpot.

There are a number of mathematical skills to the game:

- same and difference (e.g., same colour, same suites) and equality (pot and jackpot);
- numeral recognition, comparison and order, and seriation (e.g., one more, one less);
- multiplication and division with regard to pot and jackpot size for a large number of players);
- strategy, thinking and metacognition (what to play in what order).

Children observed playing this game played their cards very quickly and equally quickly recognised if a sequence was at an end. This illustrated chunking, the strategy employed by experts in order to reduce cognitive load.

DY was a new game that was brought in by Indigenous people from another area. It is played with no picture cards; the Ace counts as 1. To start this game, players put money into a central pot and are dealt two cards each. Each player adds the face value of their cards and gives themselves a score of 10 if their sum is 10 or 20, the number of points more than 10 if their sum is between 10 and 20, and the sum itself if their sum is less than 10 (e.g., a 7 and a 6 sum to 13 and score 3). The player with the highest score is considered a winner of the two-card component of the game and does not have to put in a further amount into the pot to receive his third card. Each player receives a third card and re-adds and re-scores his cards. Once again the score is 10 for any multiple of 10 and the number

(between 1 and 9) over 0, 10 or 20 otherwise (e.g., a 6, a 7 and a 4 sums to 17 and scores 7). The player with the highest score wins the pot. If two or more players have this score, they are given two more cards to use with their existing three cards to form the highest score they can with any three cards.

There is little strategy in the game except for the five card settling of draws. However, there are two important mathematics skills to the game:

- basic addition facts (including “build to 10” strategy); and
- recognising numbers in terms of tens and ones.

The whole focus on the activity is to determine how many above the next 10 the cards score. This focus on ten is crucial to addition basic facts and two-digit numeration. In particular, it reinforces the “build to 10” strategy, where two numbers are added by determining how many to the next 10 and how many more after (e.g., $8+5$ can be thought of as $8+2$ to make 10 plus 3 more to make 13), and the recognition of numbers in terms of tens and the ones left over.

This game appears to lend itself to modification to an effective practice game. For instance, students could be dealt cards one at a time (starting with two cards) until one of them can provide three cards that form a multiple of 10. This game would be particularly effective because students would be considering how many more to the next 10 so they can prepare themselves to recognise whether the next card will suffice.

Discussion

From the mathematical analysis of the card games, there appears to be evidence that students utilise mathematical skills in the playing of cards. In fact, many parts of the game cannot be played without the execution of these numeracy skills. As well, the speed at which the children could play the games indicated that the students were competent in the mathematics underlying the games. This assertion is supported by Peard (1994) who found that gamblers “exhibited a strong number sense in these contexts” (p. 259).

However, Peard (1994) also found that there was a noticeable difference between children who gambled and those who did not in relation “their understanding of the concept of mathematical fairness” (p. 258). That is, the act of gambling developed “knowledge of basic mathematical expectation.” Peard noted was that child gamblers developed language forms that described their intuitive probabilistic concepts although “strong links between the informal mathematics employed by gamblers and the formal mathematics of the classroom was not necessarily present” (p. 259). Thus, the games also develop informal probabilistic skills.

D’Ambrosio (1985) noted that there is a need to incorporate features arising out of ethnomathematics into the curriculum in order to avoid the “psychological blockade” that is so common in school mathematics. In this community, there is ample evidence of psychological, cultural and language blockades. Analysis of gambling games such as that conducted above opens the door for teachers to construct links between students’ familiar and real world concepts and formal school mathematics. Clearly, many students in this study showed through their playing of card games evidence of cognitive power and learning capabilities and positive attitudes and yet they were failing in school mathematics.

This finding should cause us to reconsider what it means to be mathematically knowledgable, for clearly many of the community children had advanced contextual or ethnomathematical knowledge that serves them in the Indigenous social and economic environment. This finding has implications for the curriculum of Indigenous community students and causes us to question, as did D’Ambrosio (1997), the assumption that Western

mathematical forms ought to be the final standard by which to judge other forms of mathematics.

There are however mathematical skills that Indigenous students need in order to function successfully in the wider Western community. As Anderson (1999) argued, “employers may require, not only mathematical skills and techniques, but also transferable skills” (p. 19). At present the most used guide for these life skills are curriculum documents. Traditionally the translation of these documents has resulted in attempts to teach Indigenous students Western school mathematics (albeit at a lower level) using the pedagogy of the *school mathematics tradition* as described by Gregg (1995). The analysis of community card games such a that undertaken above may well be a first step in developing a bridge between the sophisticated ethnomathematics practised by many Indigenous students and the Western mathematics practised in schools. It provides a tool by which teachers can explore students’ current mathematical understanding and also gives a framework to structure activities to guide students through their ZPD. Description of card games and subsequent analysis of them also provides insights into the accumulated experiences of the individual, an understanding of which has been deemed critical in developing effective pedagogues (D’Ambrosio, 1997).

Conclusions

The students who play the games RB and DY with expertise come from a group of Indigenous students whose performance in mathematical situations and on formal mathematics tests is poor. They exhibit few mathematical abilities in the classroom. In particular, they show little understanding in abstract situations (e.g., Baturo, 2003).

Two conclusions therefore emerge from the analysis in this paper. First, student understanding in these card games may form a contextual basis for instruction that can lead to more abstract understanding of mathematics. Second, assessment instruments should place mathematics understandings into card situations so that Indigenous students’ informal understandings of mathematics can be ascertained. For instance, scoring in DY could be used as a task in a diagnostic instrument to determine Indigenous students’ functional mathematical understandings and to assist Indigenous students with poor basic addition facts to gain the “build to 10” strategy.

However, the power of mathematics lies in its generic ability to apply in all situations, so mathematics understandings that are restricted in context, although useful as a beginning, should not be the end point of instruction. But will the jump from understanding mathematics in card games to understanding mathematics abstractly be too large?

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