Chance games and activities for the multiage classroom

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Abstract

The use of chance games and activities is described as a pedagogical approach which is suitable for teaching mathematics in the multiage classroom for a number of reasons. Firstly, it caters for varying student ability, *attitudes and learning styles. Secondly, it reflects a problem-driven view of mathematics and a constructivist approach to learning mathematics. Thirdly, it addresses the dilemma posed by the current plethora of mathematics curriculum documents, standards, benchmarks and learning essentials, and the paucity of learning strategies and activities offered to teachers. The article includes a number of chance activities which are analysed in terms of*

mathematical content, teaching strategies, and the range of syllabus levels and outcomes which they can satisfy.

Challenges and dilemmas

One of the challenges for primary school teachers, and more particularly those in multiage classrooms, is the designing of mathematical learning experiences which cater for students with a range of ability, attitudes, and learning styles. Mathematics abilities and achievement in a typical primary classroom may vary enormously, whether they are measured by teacher-made tests or state-wide numeracy tests (Nisbet, 2005). Similarly, attitudes to mathematics can vary greatly among students in one classroom in terms of their interest, enjoyment, anxiety, and motivation (Nisbet & Williams, in press). Although the notion of learning style is fairly new, it well recognised that students differ in their modes of perceiving, thinking, problem solving and decision making (Woolfolk & Margetts, 2007).

If the design of mathematical learning experiences is not difficult enough having to cope with such variation in the classroom, the design task is often made more problematic within the traditional conception of mathematics held by many teachers - that it is a set of facts, rules and skills (Ernest, 1989), and that it needs to be taught sequentially because of its hierarchical structure (Gagne, 1970) and taught via a transmission approach where the teacher transmits the facts, rules and skills to the students who are expected to absorb and reproduce it (Burton, 1993).

An alternative and more satisfying view of mathematics is a dynamic problem-driven view where mathematics is seen as a continually expanding field of human creation (Ernest, 1989), and can be taught via a constructivist approach in which teachers are facilitators of learning, and students construct their own mathematical knowledge through interaction with the environment (Burton, 1993). Under this approach, learning situations, problems, content and tasks are relevant, realistic, and authentic, and represent the natural

complexities of the 'real world', encouraging metacognition and self-reflection on the part of students (Murphy, 1997).

Such a dynamic, problem-driven view of mathematics and a constructivist view of learning both lend themselves well to the multiage classroom in which (i) children are challenged and stimulated by their interactions with multiage peers (Adam, Adams, Harmon & Reneke, 1999), (ii) children can collaborate in solving mathematics problems (Hoffman, 2002), and (iii) by receiving peer assistance, children can stretch their learning beyond their individual accomplishment (Dever, 1994) as described by Vygotsky's theory of the 'zone of proximal development' (Bodrova & Leong, 1996).

The philosophy of the multiage classroom makes it an ideal place for the use of games and activities as the regular pedagogy for mathematics. Games and activities fit the constructivist view because they involve use of concrete materials, real-life experiences, problem solving, discussion,
Chance games and activities by their very nature are suitable for classrooms where students vary in age, mathematical ability and mathematical attitudes.

There is currently in circulation in Australia a plethora of curriculum documents relating to mathematics and numeracy e.g. National Numeracy Benchmarks (Department of Education, Science & Training, 2000), National Statements of Learning (Curriculum Corporation, 2006), State Syllabuses (e.g. Queensland Studies Authority, 2005), and Essential Learnings in Mathematics (Queensland Studies Authority, 2007). The learning descriptors contained in these documents not only vary greatly in requirements and language used, but also lack the detailed content and pedagogy required (i) to enable teachers to cover the 'essentials',

(ii) to produce the required 'outcomes', or (iii) to assist their students attain the 'benchmarks'. Consider the range of descriptors for the topic of 'Chance' in Year 3.

* The National Numeracy Benchmarks document states that "Students use and interpret the everyday language of chance - using words such as possible, maybe, likely, unlikely - and classify familiar events as either likely or unlikely".

* The National Statement of Learning for Mathematics states that "Students make qualitative judgements about data obtained from observations or experiments and explain whether it supports or disagrees with a particular view using the appropriate language of chance".

* The Queensland Essential Learnings document states that "Chance events can be explored using predictions and statements, and predictions about chance events can be made using simple statements e.g. It is likely/unlikely that this will happen".

* The Queensland Syllabus document states that "Students identify and classify familiar events according to the likelihood of occurrence. They use the language of chance (e.g. likely, unlikely, & impossible) and make subjective judgments (e.g. comparisons, predictions, & independence of events).

One could compare this situation with giving a driver four different destinations (first dilemma) without providing either a map or a vehicle (second dilemma).

The teacher in a multiage classroom has also to contend with even more variation in learning descriptors across grade levels (third dilemma). For instance, the Essential Learnings documents provide the following learning descriptors about 'Chance':
* Year 3: Chance events can be explored using predictions and collected data; and predictions about chance events can be made using simple statements e.g. It is likely or unlikely that this will happen.
* Year 5: Chance events have a range of possible outcomes that can be described using predictions and supported by analysis of collected data; the likelihood of outcomes of events involving chance can be described using terms including likely, more likely, most unlikely, never; data collected from experiments or observations can be represented in tables and graphs and used to respond to questions about the likelihood of possible outcomes of events
* Year 7: Events have different likelihoods of occurrence and estimates of probability can be expressed as percentages, fractions or decimals between 0 and 1.

Fortunately the dilemma posed by the range of expectations in the above descriptors can be solved by the constructivist approach and, in particular, the use of games and activities as the pedagogy for 'chance'. In such an approach, students can build on their individual prior learnings and can draw their own conclusions as they deal with the problems situation posed in the game context.

In summary, the philosophy of the multiage classroom and the constructivist approach undertaken by dedicated multiage educators provide an environment in which the challenges of varying student abilities, attitudes and learning styles can be addressed, and the dilemmas posed by the range of curriculum expectations may be resolved.

Addressing challenges and solving dilemmas with games and activities

Games have always played a significant role in learning mathematics because they encourage logico-mathematical thinking (Kamii & Rummelsburg, 2008). They contribute to the development of knowledge while having a positive influence on the affective or emotional component of learning situations (Booker, 2000). Specifically, games have the potential to raise levels of students' interest and motivation (Bragg, 2007). Thus, educational games provide a unique opportunity for integrating cognitive, affective and social aspects of learning (Pulos & Sneider, 1994). Games and activities do not depend on firm pre-requisites, and as described below, can be used with students of a wide range of ages and abilities. Such flexibility is due to the motivational nature of games, and the attraction students naturally have for games and working with hands-on materials. Games also provide students with opportunities to learn specific concepts and draw conclusions at their respective levels. Repeating the games on future occasions consolidate their prior learning and provides opportunities for further learning and conceptual development.

The three games and activities included in this paper satisfy the definition of a game quoted by Pulos and Sneider, namely, "an enjoyable activity with goals, rules, and educational objectives" (p. 24). They were designed to be enjoyable and motivating for students, and to challenge their thinking in terms of their predicting and explaining what might happen. They are:
* Greedy Pig - a single-dice game for the whole class in which students take chances on the likelihood of a '2' occurring, and consider how long they are willing to take a risk;
* Dicey Differences - a two-dice game played in pairs where children weigh up the likelihood of various combinations of dice differences occurring and consider the game's fairness;
* Peg Combo - a class activity in which pairs of students each have a brown paper bag containing two red pegs and two blue pegs, and consider the likelihood of various combinations of colours when one or two pegs are selected at a time;

When these games have been used in the classroom over a period of time, students have reported an improvement in students' attitudes to chance, specifically, greater enjoyment and motivation, greater confidence when dealing with chance, and an

increased perception of the usefulness of chance in daily life. Students have indicated that the games were fun to play, interesting and enjoyable.

Teachers have noted high levels of student engagement and enthusiasm during the activities. They also noted that the activities suited the slower students as much as the high achievers.

Details of chance games and activities now follow.

Greedy Pig

Reference
Maths 300, www.curriculum.edu.au/maths300/

Suitable levels
Levels 2 to 6 (Years 2 to 10)

Materials
One six-faced die and a cup for the teacher; a record sheet for each student

Procedure
One number on the die (e.g. 2) is selected as the 'poison' number.
Everybody in the group stands. A regular six-faced die is rolled, and everyone receives the points according to the number rolled.
The die is rolled again, and everyone adds on those points to the previous points obtained. You may sit if you're satisfied with your points total so far. However, if the poison number (2) is rolled, those left standing lose all their points! Those sitting keep their points for that round.
The round continues until no one is left standing.
Every person records their points total for Round 1.
Now everyone stands to start Round 2, and the die is rolled again and everyone accumulates their points as in Round 1. Keep rolling the die until no one is left standing.
Repeat the procedure for a total of five rounds.
The winner is the person with most points after 5 rounds.

Record sheet

Round	Numbers rolled	Points
1		
2		
3		
4		
5		
TOTAL		

Mathematics involved
"Greedy Pig" is suitable for students in Levels 2 to 6 (Years 2 to 10) with the degree of sophistication of discussion increasing at the higher levels. At the lower year levels, it is a fun context for students to experience randomness and to see the range of outcomes in the sample space. In the game, students are put in the situation of considering the likelihood of a 2 occurring on the die. They make judgments and have to choose to take risks or play it safe in order to accumulate as many points as possible. The element of surprise highlights the experience of randomness of the outcomes of rolling a die.

Students have to think about a game strategy, and whether to keep standing (thereby taking a risk of a 2 being rolled on the die) or to sit down (thus playing it safe, and retaining the points accumulated so far). All through each round, they have to think about the likelihood of a two being rolled, and how long they can continue in the game before a two is rolled. Students are continually making comparisons of experimental probability and theoretical probability. "I know that a 2 will occur about one in six times, but we have had 10 rolls of the die without a 2 coming up yet! How long can I risk it?"

This game also helps students appreciate the concept of independence of chance events. That means that each roll of the die is independent of the previous rolls. The probability of getting a 2 is one in six each time, no matter what happened before, even if a 2 has not occurred for 10 or 20 rolls. Dice do not have memories!

Dicey Differences

Reference
Nisbet, S. (2006). Take a Chance: Chance Games and Activities for the Classroom. Brisbane, Queensland: Independent Schools Queensland.Suitable levels
Levels 3 to 6 (Years 4 to 10)

Materials
Two six-sided dice and a plastic cup for each pair of students

Procedure
Students play in pairs (Player 1 and Player 2).
The students take turns to roll two regular six-sided dice.
Irrespective of who rolls the dice, Player 1 wins a point or a counter (or any object) if the difference is 0, 1 or 2; Player 2 wins a point if the difference is 3, 4 or 5.
Make a tally of the results of the rolls of the dice.
Declare a winner (the person with the most points) after 10 rolls of the two dice.

Player 1: Tally for 0, 1, 2
Player 2: Tally for 3, 4, 5

.
Ask the students if they think the game is fair. Get students to complete the tables below and use them to help explain their understanding.

-	1	2	3	4	5	6
1						
2						
3						
4						
5						
6						

Difference	Frequency
	0
	1
	2
	3
	4
	5

Ask students - What does it mean mathematically for a game to be fair?
Ask students to make changes to the rules of the game so that it is "fair".

Mathematics involved

Dicey Differences is suitable for students in Levels 3 to 6 (Years 4 to 10). At the lower year levels, it is a fun context for students to experience randomness and to see the range of outcomes in the sample space. During the playing of the game, students will learn that the numbers 0, 1, and 2 are more likely to occur than 3, 4, and 5. At the higher levels, students can quantify the theoretical probabilities of each of the outcomes. There are 36 cells in the subtraction table, and the differences 0, 1, and 2 occur more than 3, 4 and 5 in the table. In fact the game is not fair; it is biased 2 to 1 in favour of Player 1 (24 to 12). Students need to think creatively as they try various combinations of differences to produce rules to make it a fair game.

This game is also an example of an activity which makes connections within mathematics - i.e. chance and number. Students need to practise their recall of basic subtraction facts, while experiencing the outcomes of random events.

Peg Combo
Reference
This activity has been adapted from "Clothes Line" published in -
Lovitt, C. & Lowe, I. (1993). Chance & Data Investigations (Vol. 1). Carlton, Vic: Curriculum Corporation

Suitable levels
Levels 1 to 6 (Years 1 to 10)
Materials
Each student needs four clothes pegs (two of one colour and two of another colour) and a brown paper bag.

Procedure
Distribute the brown paper bags with the four pegs inside to the students, and ask them to check the contents.
Single-peg activity
Tell students to take out one peg (without looking) and clip it to the side of the bag.
Ask students to hold their bags high. Count how many of each colour and record on the board in a table.
Ask students to replace the peg and draw out a peg again. Observe and record again.
Do four trials altogether, each time replacing the peg.

Trial	Colour 1	Colour 2
1		
2		
3		
4		
Total		

Get students to observe the results and compare the numbers of each colour across trials and the totals.
Discuss the variation across trials and between colours. The total should get close to 50/50 for each colour, but don't be surprised it is does not: each trial is valid of performed as above.
Discuss with students what they predict would happen if more trials were conducted.

Two-peg activity
Tell students to take out two pegs one at a time (without looking) and clip them to the side of the bag, with the first peg placed above the second peg.
Ask students to hold their bags high. Count how many of each combination and record results on the board.
Get students to replace the pegs and draw out two pegs again. Observe and record again.
Do four trials altogether, each time replacing the pegs.

Trial Same colour:
2 of Colour 1 Same colour:
2 of Colour 2 Mixed colours:
Colour 1 then Colour 2 Mixed colours:
Colour 2 then Colour 1
1
2
3
4
Total

Observe the results and compare the numbers of each combination across trials and the totals.
Discuss the variation across trials and between combinations. One would expect that there would be more mixed colours than same colours.

Discuss what would happen if more trials were conducted.

With students at higher levels, draw a tree diagram to show all possible outcomes (sample space), and determine the theoretical probabilities.

The calculations of theoretical probabilities based on the tree diagram confirm the expectation that the probability of obtaining two different colours is greater than getting the same colour.

The probability of getting Colour 1 followed by Colour 2 is 1/3.
The probability of getting Colour 2 followed by Colour 1 is 1/3.
So combining these results, the probability of mixed colours is 2/3.
The probability of getting Colour 1 followed by Colour 1 is 1/6.
The probability of getting Colour 2 followed by Colour 2 is 1/6.
So combining these results, the probability of same colours is 2/6 i.e. 1/3.

Extension of peg game
Have different numbers of each colour peg in the bag.
Students play in pairs, and each pair needs 4 blue pegs and 2 white pegs in a paper bag.
Get students to take turns to select a peg at random from the bag, and replace the peg each time.
Player A gets a point if it's Colour 1, and Player B gets a point if it's Colour 2.
Ask if the game is fair. Explain why or why not.

Change the rules to make it fair.
e.g. Change the number of pegs in the bag. Alternatively, let Player B have two turns for every one of Player A's turns.

Mathematics involved
This game is suitable for students in Levels 1 to 6 (Years 1 to 10), with the degree of sophistication of discussion increasing at the higher syllabus levels. Peg Combo provides Level 1 and 2 students with experiences of randomness and seeing the range of possible outcomes ('what might happen') in this chance situation i.e. sample space. Level 3 students can use the term 'sample space' and order the likelihood of the outcomes 'same colours' and 'different colours'. Students at Levels 4, 5 and 6 can calculate and compare theoretical probability values. The tree diagram is a useful model for the calculation. The game can be made more sophisticated for older students through investigations involving three or four pegs.

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