

# Improving students' attitudes to *chance* with *games and activities*

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**T**wo combined Year 7 classes in a Queensland primary school participated in a unit of chance lessons involving six games and activities over a period of two weeks. Evidence was found for significant short-term improvements in students' enjoyment and motivation relating to chance, decreases in anxiety about chance, and improvements in students' perceptions about the usefulness of learning about chance.

## **The importance of attitudes in learning**

Research over many years has established that attitudes play a significant role in learning mathematics (McLeod, 1992; Ma & Kishor, 1997; Zan, Brown, Evans & Hannula, 2006). McLeod's summary of research in the area includes reports of positive correlations between attitude and achievement in national assessment data at all three grades assessed (Grades 3, 7 and 11), and states that attitude and achievement interact with each other in complex ways. Ma and Kishor's meta-analysis of studies investigating the relationship between attitude toward mathematics and achievement in mathematics found that the significance of the relationship is dependent on grade level. Although the effect sizes were significantly different from zero for all grade levels, the relationship might not be important for students in Grades 1 to 6, but might be practically meaningful for students in Grades 7 to 12. Ma and Kishor's conclusion highlights the importance of attending to attitudes in teaching students in Year 7 (i.e., those participating in this study).

Each of the commonly accepted elements of attitudes — interest, enjoyment, motivation to learn, confidence, anxiety, and task value — has been identified in research as relevant to success in learning. In their discussion of the role of attitudes in learning, Woolfolk and Margetts (2007) indicate that students' interest in, enjoyment and excitement about what they are

learning is one of the most important factors in education. They also indicate that when students' motivation levels are increased, they are more likely to find academic tasks meaningful. Hence students try to benefit from engaging in academic tasks. Woolfolk and Margetts also note that: student motivation is affected by feelings of task value (students' perceptions of the usefulness of what they are learning); and, that increased levels of anxiety have a negative affect on school achievement. McLeod (1992) reports that student confidence correlates positively, and quite strongly, with achievement in mathematics. Overall, there is clear evidence to show that attitudes are integrally linked to students' learning and achievement, including that in mathematics.

The development of instruments to measure attitudes to mathematics has been undertaken by researchers such as Fennema and Sherman (1976), and Tapia and Marsh (2004). The instruments were used to identify the attitude constructs mentioned above: enjoyment, confidence, perception of usefulness, anxiety and motivation.

The nature of the link between attitudes and learning has been described by Ajzen & Fishbein (2000) in their "theory of personal action" which states that attitudes influence intentions, which in turn influence behaviour. Behaviour then leads to personal experiences which in turn have an effect on attitudes (see Figure 1).

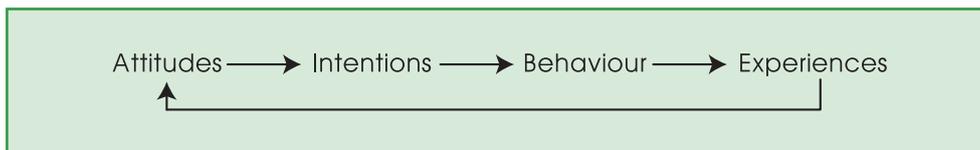


Figure 1. The attitudes-behaviour cycle.

Applying the attitudes-behaviour cycle to the case of learning mathematics, two scenarios have been proposed: a positive attitude cycle and a negative attitude cycle (Nisbet, 2006a). In the positive attitude cycle, a student with positive attitudes to mathematics (i.e., he/she likes mathematics) has the intention to do well, hence exhibits positive behaviour, and then experiences success. The success in turn improves attitudes even more, and the cycle continues. In the negative attitude cycle, a student who dislikes mathematics has little intention of trying in class, does little work, and experiences failure, which, in turn, produces more negative attitudes. These cycles are represented in Figures 2 and 3.

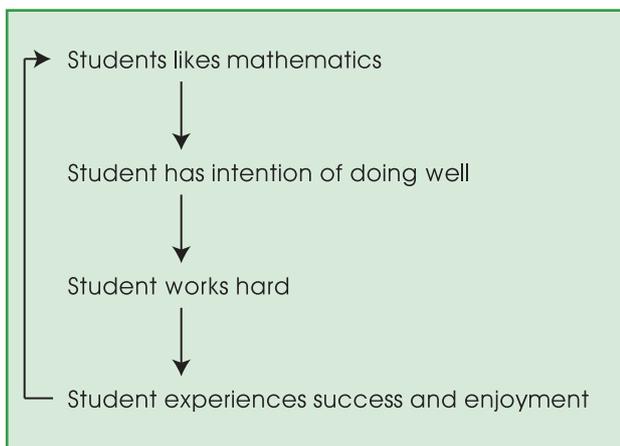


Figure 2. Positive attitude cycle.

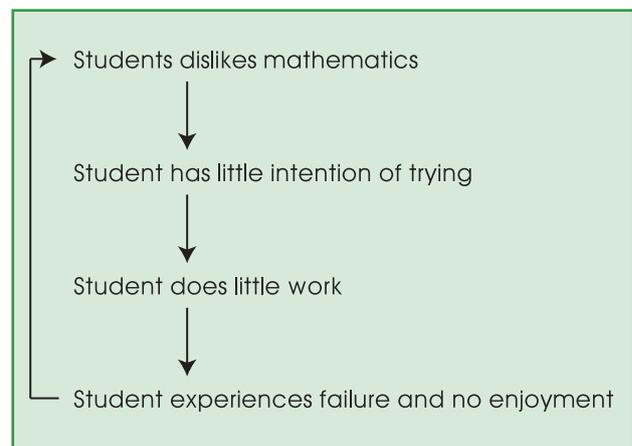


Figure 3. Negative attitude cycle.

## The study on chance

A study was undertaken to implement a series of chance games and activities in a Year 7 classroom, and investigate the students' knowledge about probability concepts, as well as their attitudes to chance. Initially, the project involved selecting a set of appropriate learning activities to develop key probability concepts which are integral to the probabilistic thinking framework by Jones, Thornton, Langrall & Tarr (1999). These were randomness, likelihood, sample space, experimental probability, theoretical probability, and independence.

This article reports on the "attitudes" aspect of the project. The project investigated the extent to which the "attitudes-behaviour" cycle proposed in the theory of personal action (Ajzen & Fishbein, 2000) applied to students' learning of chance in the classroom. In particular, it was concerned with the strength of the link between learning experiences and attitudes, and with observing and reporting on any changes in attitudes that occurred during the project. Data on students' attitudes were collected before and after the set of learning episodes.

The aspects of attitudes considered in the project were enjoyment, motivation, confidence, anxiety, and perceptions about the usefulness of learning about chance.

In the implementation stage of the study, one of the two researchers taught the first lesson consisting of two games/activities to the combined class. A day or two later the lesson was repeated in individual classes by each teacher. Three of these introduction and practice cycles were used to present six activities over an eight day period. The participants in the project were two experienced Year 7 teachers in a double classroom in a Queensland suburban state primary school, and their classes. [Year 7 is the final year of primary school in Queensland.] There were 58 students in the combined class, consisting of 31 boys and 27 girls.

## Chance games and activities in the classroom

The selection of games and activities as the pedagogical approach for the study was deliberate. Games have always played a significant role in mathematics and its learning because they encourage logico-mathematical thinking (Kamii & Rummelsburg, 2008), contribute to the development of knowledge while having a positive influence on the affective or emotional component of learning situations (Booker, 2000), and can 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). The games and activities included in this study satisfy the definition of a game as, "an enjoyable activity with goals, rules, and educational objectives" (Pulos & Sneider, p. 24).

The six probability activities used in this study were designed to be enjoyable and motivating for the students, and to challenge them to predict and explain what might happen. Listed below are the games/activities used in the project.

### **Cycle 1 activities**

- *Greedy Pig* — a dice game for the whole class in which students take chances on the likelihood of a “2” occurring, and consider for how long a time, in terms of the number of die rolls, they can take risks.
- *Get Your M&Ms* — a two-dice game played in pairs where students consider the likelihood of various combinations of dice sums occurring.

### **Cycle 2 activities**

- *Dicey Differences* — a two-dice game played in pairs where students assess the likelihood of various combinations of dice differences occurring and consider the game’s fairness.
- *Multiplication Bingo* — a class game in which each student fills in 16 different numbers (multiplication answers) from 0–99 on a 4 × 4 bingo board, after considering the likelihood of their numbers being selected from a deck of multiplication fact cards (0 × 0 to 9 × 9).

### **Cycle 3 activities**

- *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.
- *Dice Rolling* — students in groups predict the results from 60 dice rolls, then experiment with 20, 40 and 60 dice rolls in turn, and compare the experimental data with their predictions.

Details of chance games and activities are available on following pages.

## **Collecting data on students’ attitudes to chance**

During the project, data on students’ attitudes to chance were collected through:

- student surveys (pre & post),
- interviews with selected students (post),
- interviews with teachers (pre & post), and
- teachers’ journals.

The student survey consisted of 10 questions — two questions for each of five attitude constructs:

1. enjoyment and interest,
2. confidence,
3. perception of usefulness of chance,
4. anxiety, and
5. motivation,

These five constructs were based on the work of Fennema and Sherman (1976), and Tapia and Marsh (2004).

At the end of the project, interviews were conducted with eight students, of mathematics ability levels (from low to high ability), selected because of their interesting responses to the pre-project survey. The interview included questions regarding their thoughts on the chance lessons overall and individually; their levels of enjoyment of each of the activities; and their reasons for their responses.

The teacher interviews consisted of questions concerning the five attitude constructs (enjoyment and interest, confidence, perceptions of usefulness, anxiety, and motivation) in relation to their [...continues p. 35]

# Greedy Pig

## Reference

Maths 300, [www.curriculum.edu.au/maths300/](http://www.curriculum.edu.au/maths300/)

## Materials

One six-faced die and a cup; 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 are 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). In the game, students are put in the situation of considering the likelihood of a 2 occurring on the roll of a 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 TO DATE). 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!

# Get Your M&Ms

## Reference

Nisbet, S., Jones, G., Thornton, C. & Langrall, C. (2000). A dicey strategy to get your M & Ms. *Australian Primary Mathematics Classroom*, 5 (3), 19–22.

## Materials required

“Get Your M&Ms” game board  
Two six-faced dice and a plastic cup per pair of students  
One packet of mini M&Ms per pair of students (or sultanas where schools have food rules which restrict the consumption of chocolate in the school).

## Procedure

The dice game is played in pairs.  
Both players place 12 M&Ms in the boxes of their respective sides of the board in any way — with as many M&Ms as they like in each box, noting that two dice will be rolled and the numbers added.  
Player 1 rolls two dice, adds the numbers, then removes an M&M off the board if there is one in that box on the board. M&Ms can only be removed one at a time.  
[Do not eat the M&Ms until after playing the game at least twice.]  
Player 1 can keep rolling each time he/she is successful at removing an M&M.  
Player 1 passes the dice to Player 2 when he/she is unsuccessful.  
Player 2 can keep rolling each time he/she is successful at removing an M&M.  
Player 2 passes the dice back to Player 1 when he/she is unsuccessful.  
Players 1 & 2 continue to play in that way.  
The winner is the first player to remove all his/her M&Ms off the board.  
Play the game at least twice.

## Game board

Player A											
1	2	3	4	5	6	7	8	9	10	11	12
1	2	3	4	5	6	7	8	9	10	11	12
Player B											

## Discussion

After playing the game, discuss with the class the outcomes from the game — the numbers that occurred the most times and the numbers that occurred the least number of times.

What strategies did students use to maximise their chances of winning?

## Calculations

Students can then work out the theoretical probabilities of each of the sums occurring. Firstly, fill in the sums of the two dice in the 6 × 6 table below.

+	1	2	3	4	5	6
1						
2						
3						
4						
5						
6						

Now count how many times each sum appears in the addition table and record that information in the frequency table below.

Sum of dice	1	2	3	4	5	6	7	8	9	10	11	12
Frequency												
Probability (fraction)												

Finally, explain a good long-term strategy to win this game in terms of the information in this table. Further details of the game and its use in class are available in Nisbet, Jones, Langrall & Thornton (2000).

## Mathematics involved

“Get Your M&Ms” is suitable for students in Levels 3 to 6 (Years 4 to 10). At the lower levels, it is an enjoyable context in which students can experience randomness and to see the range of outcomes in the sample space. They need to consider the likelihood of the various outcomes from 1 to 12 as they spread the M&Ms across the board, and try to predict which positions on the board are most likely to occur with the sum of the rolled dice. If students do not realise initially that a sum of 1 is impossible, they will certainly realise this during the first game. During the playing of the game, they will learn that the numbers in the middle of the board are more likely to occur than the numbers at the ends. At the higher levels, students can quantify the theoretical probabilities of each of the outcomes. There are 36 cells in the addition table, and “7” is the most frequently occurring sum; it occurs 6 times in the table. Hence its theoretical probability is 6/36 or 1/6.

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 addition facts, while experiencing the outcomes of random events.

## Dicey Differences

### Reference

Nisbet, S. (2006b). *Take a chance: Chance games and activities for the classroom*. Brisbane, Queensland: Independent Schools Queensland.

### 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 views.

-	1	2	3	4	5	6	Difference	Frequency
1							0	
2							1	
3							2	
4							3	
5							4	
6							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 an enjoyable context in which students can 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.

# Multiplication Bingo

## Reference

Selby, J. & Flavel, S. (2003, January). *The multo game*. [Presented at the 19th Biennial Conference of Australian Association of Mathematics Teachers, Brisbane, Queensland.] Also see Curriculum Corporation, Maths 300 set.

## Materials

Bingo boards ( $4 \times 4$  grids) for each student.  
One pack of 100 cards for the teacher containing the 100 basic multiplication facts (i.e., single digit facts) from  $0 \times 0$  to  $9 \times 9$  (including the turn-arounds, i.e., commutative pairs such as  $2 \times 3$  and  $3 \times 2$ , and zero facts).

## Procedure

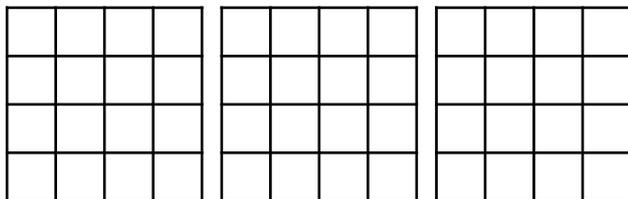
Students first insert 16 different numbers between 0 and 99 on their first Bingo Board — numbers they think may be the answers to the multiplication cards to be read out by the teacher.

The teacher shuffles the pack of 100 cards and then reads them out one at a time from the pack, pausing for students to work out their basic facts and mark off the numbers.

If the teacher reads out, “7 fives,” the students cross off 35 on their boards if they have it.

Students call out “Bingo!” when they have a row, column or diagonal of four numbers crossed out.

The first student to call out “Bingo!” is the winner.



Board 1

Board 2

Board 3

After playing the game once, discuss which numbers are good to have on the board — those which have more cards in the pack and have a greater likelihood of being selected. The best number is zero because there are 19 cards with zero facts ( $0 \times 0$ ,  $1 \times 0$ ,  $2 \times 0$ ,  $3 \times 0$ , etc. plus and  $0 \times 1$ ,  $0 \times 2$ ,  $0 \times 3$ , etc. The next best numbers have four cards and are 6 ( $1 \times 6$ ,  $6 \times 1$ ,  $2 \times 3$ ,  $3 \times 2$ ); 8; 12 ( $2 \times 6$ ,  $6 \times 2$ ,  $3 \times 4$ ,  $4 \times 3$ ); 18; 24.

Other numbers with a reasonable likelihood of being selected are 16 and 36.

Then play the game again so that students can use the “likely” numbers.

Then discuss the best positions to place the “likely” numbers. Some may place them all in one row or column. Others may place them in the middle four cells or four corners, because they are one the diagonals as well as rows and columns.

At a subsequent lesson, ask the students to devise some game boards by fictitious students. Then discuss which one would be the most likely to win and why.

## Mathematics involved

Multiplication Bingo is suitable for students in Levels 3 to 6 (Years 4–10). It provides opportunities to discuss the notions of likelihood, in terms of which numbers are most likely to occur, least likely, or even impossible (e.g., prime numbers). The notion of randomness is relevant too because the cards are shuffled and will be read out in random order.

The set of cards illustrates the complete sample space with 100 cards. However, there is a need to recognise that some cards give the same answers. For example, the cards with  $2 \times 8$ ,  $8 \times 2$  and  $4 \times 4$  each give an answer of 16. Similarly, the cards with  $1 \times 8$ ,  $8 \times 1$ ,  $2 \times 4$  and  $4 \times 2$  each give an answer of 8.

The game allows students to calculate theoretical probability of each of the numbers in terms of how many cards are present in the pack with a particular answer. For example, there are 19 cards in the pack of 100 cards with the answer of zero, so the probability of selecting a card with an answer of zero is 19%. The probability of selecting a card with an answer of 24 is 4% because there are 4 cards out of 100 that give the answer 24. The probability of getting a prime number larger than 7 (e.g., 11, 13, 17, and so on) is 0% (impossible). The prime numbers 3, 5, and 7 have a probability of 2% because they each have two cards in the pack (for example,  $1 \times 3 = 3$  and  $3 \times 1 = 3$ ). The probability of getting a number less than 100 is 100% (certain).

Other positive dimensions to this game are:

- (i) its overlap with the Number strand. Students are practising their recall of multiplication basic facts during the game.
- (ii) the use of strategic thinking in the choice and location of the numbers.
- (iii) discussion of the boards of fictitious students.

This means considering the likelihood of different numbers being read out.

This game can also be played by computer simulation, where students create their own boards by computer, which stores the boards for re-use. Thus students can determine which board is best in the long run. Multiplication Bingo is also available from Curriculum Corporation, Maths 300 set.

# Peg Combo

## Reference

This activity is similar to one published in:  
 Lovitt, C. & Lowe, I. (1993). *Chance and data investigations, Vol. 1*. Carlton, Vic: Curriculum Corporation

## 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 do not be surprised if it does not).

Discuss what they predict would happen if more trials were conducted.

### Two-peg activity

Tell students to take out two pegs (without looking) and clip them to the side of the bag, the first peg above the second.

Ask students to hold their bags high. Count how many of each combination and record 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 Col. 1	Same colour: 2 of Col. 2	Mixed colours: Col. 1 then Col. 2	Mixed colours: Col. 2 then Col. 1
1				
2				
3				
4				
5				

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.

Draw a tree diagram to show all possible outcomes (sample space), and determine the theoretical probabilities.

## Tree diagram

The calculations of theoretical probabilities based on the tree diagram above 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 is Colour 1, and Player B gets a point if it is 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 harder through investigations involving three or four pegs.

# Rolling Dice

## Reference

Nisbet, S. (2006b). *Take a chance: Chance games and activities for the classroom*. Brisbane, Queensland: Independent Schools Queensland.

## Materials

One six-faced die and a cup per pair of students.

## Procedure

Students work in pairs.

### Make a prediction

Ask students to predict what they would get if they rolled a six-sided die 60 times, i.e., how many ones, twos, threes, fours, fives, and sixes? Write your estimates in the table.

Face of die	1	2	3	4	5	6
Prediction						

### Conduct an experiment

Ask students to roll a six-sided die 20 times and record the number of times each of the numbers from 1 to 6 occur, using the tally sheet.

Face of die	1	2	3	4	5	6
Tally marks						
Tally total						
Experimental probability (%)						

### Calculations

Now ask students to calculate the experimental probabilities for each number as percents and insert the results in the table. Ask students to check their calculations by calculating the sum of the six probabilities.

### Continue the experiment

Ask students to roll the die another 40 times, and calculate again the experimental probabilities for each number as percents. Record using the table provided.

Face of die	1	2	3	4	5	6
Tally marks (40 rolls)						
Tally total (40 rolls)						
Experimental probability (from 40 rolls, %)						

Add the tally totals for 40 rolls from this table to the tally totals for 20 rolls from the previous table. Insert the totals for 60 rolls below, and calculate the experimental probabilities from 60 rolls.

Face of die	1	2	3	4	5	6
Tally total (60 rolls)						
Experimental probability (from 60 rolls, %)						

### Discussion

Ask students to comment on a comparison of the calculations of experimental probabilities, and also compare with the theoretical probabilities.

### Mathematics involved

This activity is suitable for students in Levels 2 to 4 (Years 3 to 7) because it can be conducted to varying degrees of sophistication. It is an example of a simple probability experiment in which one observes the outcomes of a single event over many trials. It provides students with opportunities to make predictions and comparisons. It also is a context to use the language of chance, e.g., likely, unlikely, impossible (getting a 7), certainty (getting a number between 1 and 6 inclusive), in a meaningful way. It also allows students to experience the phenomenon of independence (each roll is independent of previous spins), see the difference between experimental and theoretical probability, and see the need for conducting a large number of trials in an experiment.

It should be emphasised during the activity that each sample of trials is valid, even those whose results do not resemble the theoretical probabilities.

observations of the students during the initial teaching sessions, and their experiences whilst conducting the games and activities in the repeat sessions. The teachers were also requested to keep a journal, recording their reflections on students' attitudes to the activities, and their perceptions of the teaching and learning process.

## What the students reported

A pre-post comparison of the survey data using paired *t*-tests revealed that statistically-significant changes in students' attitudes had occurred ( $p < .05$ ). At the end of the project, students reported:

- greater enjoyment when learning about chance;
- less anxiety and worry when working on chance;
- greater motivation and desire to learn more about chance in class; and
- an increased perception of the usefulness of chance in their lives.

The increase in student confidence was not statistically significant ( $p > .05$ ).

The consensus among the students during their post-project interviews was that the games were easy, fun to play, interesting and enjoyable. The high-ability students rated the games and activities slightly higher than the other students. "Greedy Pig" and "Get Your M&Ms" attracted the highest ratings, and students' explanations related to the inherent sense of challenge and motivation provided by the games, and the boosting of confidence that students felt as a result.

Other students commented that the fun arose from not knowing what to expect during a game, not realising at the time that they were learning from the game, and being able to eat the M&Ms at the end of the game. Another student said the games taught him about risk taking. Students commented that the topic of chance was useful because having a strategy was a faster way of winning a game, and that they might use game strategies in the future.

"Rolling Dice" and "Peg Combo" attracted lower ratings (mostly 2 or 3 out of a possible 5) compared to the other activities such as "Get Your M&Ms" (mostly 4 or 5) as they were seen to be less interesting. Often, students had played similar dice-rolling games before.

Overall, there was evidence of an improvement in students' attitudes to chance, namely, greater enjoyment and motivation, increased perception of the usefulness of chance, and less anxiety, over the duration of the project.

## What the teachers reported

During the post-project interview, one teacher reported that the children enjoyed the activities mainly because they provided a "fun" way of learning, which had the children involved. She also mentioned that at times in the repeat sessions some children were not keen on writing down their responses, which were probably the same as those from the day before. The other teacher commented that the activity approach gave the slower students something to enjoy as well as the more able students, and that the students appeared more confident with the activities during the repeat lessons.

In her journal, the first teacher noted how the children enjoyed the activities, especially "Greedy Pig" and "Get Your M&Ms," and were really keen to

play them again in the follow up sessions. She noted the students were fully engaged and motivated in “Peg Combo” and “Rolling Dice.” She was pleased and amazed that some of the thinkers in the class spent considerable time writing and responding to the questions on the activity sheet. She noted student enthusiasm, challenge and competitiveness across all levels of ability especially with “Multiplication Bingo.” The other teacher also noted high levels of enthusiasm and student participation in the games overall.

Enjoyment and motivation were perceived by the teachers to be noticeably present while the students were involved in the games and activities.

## Implications for the classroom

The project demonstrated that students’ attitudes to chance can be improved by the use of chance games and activities (at least in the short term). Teachers should therefore use such activities to address attitude problems, knowing that it is likely that students’ attitudes to learning about the mathematics of chance will improve. Teachers can then capitalise on the improved attitudes to enhance levels of student intention, engagement and success as hypothesised in theory of personal action (Ajzen & Fishbein, 2000). As indicated in the positive attitude cycle in Figure 1, if students like mathematics, they are more likely to have the intention of doing well, work hard and experience success and enjoyment.

Teachers can also reflect on the fact that this study, which utilised a game/activity approach in the classroom, revealed a significant reduction in students’ anxiety about learning the mathematics involved in chance.

Teachers as well as the students reported high levels of student interest, enjoyment and motivation during the project. However, the teachers noticed that with some students, interest waned a little when they stopped playing the game, and had to start thinking about the outcomes and results of the game. In such situations, teachers can sustain students’ interest by maintaining the links between the game (experimental probability) and the thinking (theoretical probability). This can be done through class discussion and student reflection on the game, the theory behind it, and strategies students can employ to improve their chances of winning the game.

The project also demonstrated that competitive games (e.g., “Greedy Pig” and “Get Your M&Ms”) attract more interest and response in students than non-competitive activities (e.g., “Dice Rolling” and “Peg Combo”). This might be because of the element of competition, randomness and surprise inherent in the games. The implication for teachers is that, when attitudes need to be dealt with in the classroom, it is worth the effort for teachers to seek the competitive game as the starting point and stimulus for thinking in a learning episode.

Teachers can use chance games and activities to improve students’ perceptions of the usefulness of chance as a topic for study. Following the learning episodes involving games and activities, teachers should utilise the many opportunities which exist in subsequent lessons to discuss the use of probability theory in its many applied fields, including statistics, science, finance, social science, risk assessment, reliability theory, quality control, and recreation. In the case of recreation, teachers can help students become aware of the futility and dangers of gambling because of the extremely low probabilities of winning and the risks of addictive behaviour.

This article highlights the potential for chance games and activities to improve students’ attitudes to learning about chance, to motivate students

to become more engaged in the study of chance, and, possibly, to experience greater success in the topic. The authors are currently preparing a report on students' conceptual understanding and skills in chance observed during the project.

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