

F	1	2	3	4	5	6	B6
---	---	---	---	---	---	---	----

What are the odds?

Strand:

Chance and data

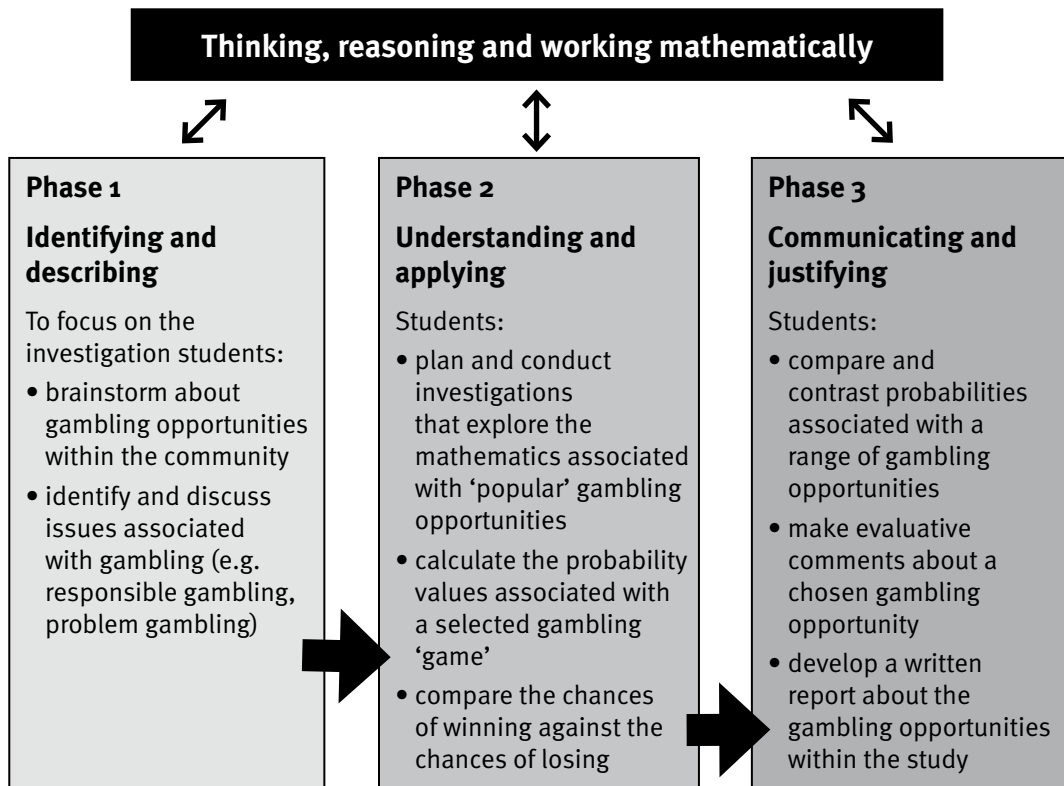
Purpose:

The main purpose of this module is to allow students to analyse a range of commonly available gambling opportunities and determine the numerical probabilities of several of them.

They will investigate and calculate probabilities in relevant situations. The students will use probability data to contrast and compare various gambling opportunities in relation to risk, potential to win or lose and the value of prizes compared to the risk.

Overview of activities

The following table outlines the activities in this module about common gambling opportunities and the mathematics associated with them. It illustrates the way in which these are organised in phases and how they promote **thinking, reasoning and working mathematically**.



Core Learning Outcome

This module focuses on thinking and reasoning about a range of gambling opportunities. The related Level 6 Chance core learning outcome is:

CD 6.1 Students model and determine probabilities for multi-outcome and compound events and justify decisions.

Core Content

Chance

Likelihood

- language of chance
 - o multi-outcome events
 - o compound events
 - o conditional probability (replacement or non-replacement)
- theoretical probability of multi-outcome and compound events
- probability models
 - o lists, tables, tree diagrams
 - o computer simulations
 - o experiments

Judgements

- quantitative judgements
 - o predictions and justifications
 - o experimental and theoretical probability links
 - o extrapolations from simplified explorations

Assessment

The assessment advice in the following table is based upon the *Elaborations* provided by the Queensland Studies Authority on its website (www.qsa.qld.edu.au).

The *Elaborations* are a resource that supports teachers to unpack each core learning outcome. They include statements about what students should know and what they should be able to do with that knowledge. The latter set of statements can be used as assessment criteria when determining the quality of students' learnings.

CHANCE Topic

Core learning outcome	What students should know	Assessment criteria What students should be able to do
<p>CD 6.1 Students model and determine probabilities for multi-outcome and compound events and justify decisions.</p>	<p>Students know: 6a different ways to model multi-outcome and compound events involving probability</p>	<ul style="list-style-type: none"> o explain and model multi-outcome events o explain and model compound events o explain the difference between multi-outcome events and compound events and provide examples
	<p>6b methods for calculating probabilities for multi-outcome events and compound events</p>	<ul style="list-style-type: none"> o identify when the probabilities of different outcomes need to be added to effect a specified result (multi-outcome events such as drawing a heart from a full deck of cards) o identify when the probabilities of different outcomes need to be multiplied to calculate the probability of a specific event (compound events such as rolling two fours in a row) o determine probabilities for multi-outcome events by adding the probabilities of the component events o determine probabilities for compound events by tree diagrams and multiplication o explain that the sum of probabilities for outcomes in a sample space will be 1
	<p>6c conditional probability relates to the occurrence of one event being dependent on the occurrence of another event</p>	<ul style="list-style-type: none"> o identify situations where conditional probabilities apply (such as Lotto draws) o demonstrate and explain how the conditional probabilities change when a number of consecutive events (such as Lotto draws) occur without replacement o use conditional probability to work out the chances of a specific number of events occurring together (such as a specific Lotto draw of six numbers) o explain the connection between odds and probabilities o analyse activities involving chance in common social contexts such as medicine and gambling
	<p>6d theoretical, conditional and experimental probabilities provide numerical values for the likelihood of occurrence of multi-outcome and compound events</p>	<ul style="list-style-type: none"> o calculate the probability of a range of multi-outcome and compound events o make statements or predict future outcomes based on the given or calculated probabilities o collect and analyse experimental data and estimate the probabilities of specific events
	<p>6e predictions, statements and decisions can be supported using theoretical, conditional and experimental probabilities.</p>	<ul style="list-style-type: none"> o justify decisions or predictions of future events by using given or calculated probabilities o collect experimental data to estimate probabilities to support statements or predictions

Contributions to the valued attributes of a lifelong learner

Through engagement with activities in this module, students develop the following attributes:

Knowledgeable person with deep understanding

- understands the concept of chance
- is able to make judgements about likely outcomes

Complex thinker

- analyses and organises information

Active investigator

- uses experiments and other tools to investigate questions
- accesses information from a variety of sources

Responsive creator

- uses a variety of displays to present information to a chosen audience

Effective communicator

- presents data collections to others using different data displays
- uses data displays as a means of communicating information

Participant in an interdependent world

- works independently and in groups, and acknowledges the ideas of others

Reflective and self directed learner

- looks for and recognises ways of “working mathematically” in everyday life

Background information

Gambling in Australia

Gambling is an integral part of Australian culture. It is an activity that has saturated the everyday and has impacted on the realities of children and young people.

*Today's juveniles are the first generation to be raised in an environment where legalised gambling is so pervasive, readily accessible and socially acceptable.*¹

For many people, gambling is a recreational interest that provides important opportunities for social interaction, and is a harmless and enjoyable pastime. However, others may gamble excessively, resulting in high economic, social, family and personal costs. According to the *Queensland Household Gambling Survey (2001)* 0.83% of the Queensland adult population or about 22,000 people experience problems with their gambling².

It is difficult to define 'problem gambling' because behaviours and situations that harm some individuals may not cause problems for others. However, a problem gambler can be defined as 'a person whose gambling has caused unmanageability or problems in some areas of ...life, e.g. financial, marital, work, emotions, health, loss of identity, depression etc.'² For the purpose of this module, responsible gambling could be defined as participating in gambling practices that do not result in negative health outcomes.

To read more about gambling's impact on young people refer to the Introduction section of your *Responsible Gambling Teaching Resource Kit*.

Students and disclosure

If students make personal disclosures about gambling-related issues, professional support for the family or child is available through the Gambling Helpline (1800 222 050), local Gambling Help services and other community agencies such as Gam-Anon. Students may also access the Kids Help-line (1800 551 800).

Contact numbers for Gambling Help services are provided on a poster in the folder of your *Responsible Gambling Teaching Resource Kit*.

Details of help services can also be accessed via the Responsible Gambling website (<http://www.responsiblegambling.qld.gov.au>)

School authority policies

Be aware of and observe school authority policies that may be relevant to this module.

Education Queensland policies can be found at (www.education.qld.gov.au/corporate/doem/sindex/m-ind.htm).

For policies and guidelines for the Catholic sector, refer to the Queensland Catholic Education Commission website (www.qcec.qld.catholic.edu.au/policies.htm).

Responsible Gambling Education Principles and Guidelines should be referred to. These can be found in section 2 of your Teaching Resource Kit or accessed via the Responsible Gambling website (www.responsiblegambling.qld.gov.au).

¹ Jacobs (2000) *Juvenile Gambling in North America: Analysis of long term trends and future*, *Journal of Gambling Studies* 16 (2/3) pp 119-152.

² Queensland Treasury (2001) *Queensland Household Gambling Survey*, Queensland Government, p.2.

³ Symond, P. (1997) *A synopsis of problem/compulsive gambling*, in K. Healey (ed.), *Gambling: Issues for the Nineties*, The Spinney Press, Sydney.

Phase 1 Identifying and describing

What is gambling and why do people gamble?

Students

- ▶ Have the students brainstorm about gambling and their observations about the types of gambling that are legal within the community.
- ▶ Have students make suggestions about why people take up gambling and why they think some gamble too much.

Teaching considerations

- In your class discussion, refer to Resource Sheet 1 and OHTs 1 and 2. The orienting activities in Idea Sheet 1, *The games we play*, will provide you with some discussion points around these resources.
- As students share their perceptions about gambling, teachers should be sensitive about privacy issues and stop students if they seem to be sharing information that is too personal about their family beliefs and practices.
- The students should be encouraged to access the Responsible Gambling website (<http://www.responsiblegambling.qld.gov.au>) and read the information provided in *School Stuff*.
- Investigate some of the history of gambling using Resource Sheets 3 and 4 and OHT 4. The orienting activities in Idea Sheet 2, *As time goes by*, will provide you with some discussion points around these resources.
- They should also refer to the materials in the *Responsible Gambling Teaching Resource Kit* for information about gambling in the community. Students might watch and discuss the video programs or listen to the CD material. Section 12 of the Resource Kit provides a brief synopsis of the audiovisual contents.
- Discuss the issue of problem gambling with the students – and why it is considered a problem. Refer to OHT 24 for a definition of problem gambling. You should also consider using Resource Sheets 10 and 24 in your Resource Kit to assist with this discussion.
- Students can explore the issue of problem gambling by reading the *Melbourne Age* article (Resource Sheet 41) entitled '*How Government is fighting problem gambling*'. The students should identify the amounts of money associated with poker machine use in Victoria, why the government is concerned and how it is trying to deal with the problem. Resource Sheet 42 provides information on what the Queensland Government is doing to promote responsible gambling. More information on these initiatives is provided on the Responsible Gambling website (<http://www.responsiblegambling.qld.gov.au>)
- The students can also use the *Know your limit, play within it* articles (Resource Sheet 43) as the basis for discussions about responsible gambling. These articles are part of a series of articles about the topic. Students should identify the criteria for responsible gambling discussed within the articles. OHT 23 provides a definition of responsible gambling. The Gamble Responsibly section of the Responsible Gambling website provides more information on responsible gambling.
- Have the students plan and conduct some research to find out about people's reasons for and understanding about the gambling opportunities they engage with. They should design a limited number of questions to pose to people – beginning with their own families if they are participants. The questions might address the following issues:
 - o Why they are gambling?;

- o Their personal views and thoughts about gambling (i.e. fun, risky, exciting, a worry, luck/bad luck etc);
- o Whether they know their chances of winning when they gamble;
- o Whether they know their chances of losing before they gamble;
- o How often they gamble;
- o Whether they set aside specific funds for gambling within the family budget each payday;
- o Whether they have ever gambled too much;
- o Whether they have had any major wins;
- o How long it has been since they won a prize of \$100 or more.

Discuss the language and concept of chance

Students

- ▶ Discuss the concepts of *luck* and *risk* with the students.
- ▶ Discuss theoretical probability and odds and how they apply to common gambling opportunities.

Teaching considerations

- It is important that students begin to understand that any form of gambling involves taking risks. They need to understand the mathematics of any gambling opportunity to understand the risk.
- Have students collate and analyse the data from their research and make general statements about the various views. It is likely that most people involved in ‘social’ forms of gambling such as Lotto, Scratch-It tickets and the Pools have no idea about their real chances of winning or losing. The students should discuss and comment on this ‘blind trust’ by the people who are gambling. They might like to reveal some of the odds and note people’s reactions (e.g. more than 94% of Lotto tickets will be losers – based on the published odds of one in 18 for winning any prize by buying a 12-game entry). The students should discuss whether they will be future participants if they have only a 6% chance of winning any prize – *is this value for money?*
- Assist students interpret the given odds of winning that are listed in Resource Sheet 29. They should also calculate the chances of losing in each of these games (if the odds of winning a prize are 1 in 18, then the odds of losing are 17 in 18 or 94.4%).
- Students can explore some of the games discussed in that brochure by visiting the <http://www.phm.gov.au/gambling/> website. If they play the Lotto game on the site, they can observe firsthand how difficult it can be to select enough winning numbers to win a prize. One of the facts provided to students as they play this game is that Australian gamblers lost \$12 billion in 1999 alone while spending \$103 billion gambling – that is about \$7,300 per adult in the country.

Phase 2 Understanding and Applying

Why are the chances (odds) of winning the really big prizes so low?

Students

- ▶ Discuss the concept of gambling games that have very large top prizes;
- ▶ Assist students work out the chances of winning and losing associated with multi-outcome gambling games (such as selecting a ‘street’ of numbers, or odds/evens or red/black in roulette)

- ▶ Assist students work out the chances of winning and losing associated with compound event gambling games (such as lotto and keno).

Teaching considerations

- Have students focus on a game such as Lotto which has large top prizes. Have them use the details from the Saturday Lotto draw 2477 on the 16th April 2005 to work out how many standard entries are needed to lose to cover the prize pool payout. The Golden Casket website (<http://goldencasket.com>) can provide historical information about any year's results – students should click on the 'Results' icon and then link to the results file. Resource Sheet 39 provides a table of results about the 2004 results. Only the first six numbers are considered, not the two supplementary numbers.

• **Teachers must be diligent in their monitoring of students' activities on the Golden Casket website and take care that they do not attempt to register on-line for any forms of gambling. Students should be made aware that it is against the law for people under 18 years of age (i.e. minors) to play the games or be sold tickets. Minors also cannot collect any winning prizes.**

- If the cost of a standard entry (12 game panels) is rounded to \$6, then more than 550,000 similar entries would need to lose to match only the total of the top prize (more than \$1.1 million was won by three separate entries). Students could work out similar data to cover the other prizes:
 - 55 entries won the 2nd division worth \$15,437.25;
 - 1269 entries won the 3rd division worth \$1,238.30;
 - 68 184 entries won the 4th division worth \$39.20; and
 - 172 066 entries won the 5th division worth \$24.75.

(Data copied from the results published in *The Courier Mail* on Tuesday 19 April 2005).
- These calculations cover only the prize payouts, but they indicate the large numbers of losing entries necessary to provide such large prizes. Other money collected through sales is set aside before the values of the prizes are calculated. This money is used to cover costs, pay government fees, charges and taxes, and also to contribute to worthwhile community projects.
- OHTs 22a and b can also be used to stimulate discussion around this topic.
- The students should be very clear that they should not have high expectations about winning large prizes if they decide in the future to participate in these games. The data they gathered from Phase 1 should indicate that many participants are modest gamblers because their own experiences have demonstrated the high risk of losing.
- Use Resource Sheet 44 to explore the set-up of a roulette wheel with the students. They should use the data and the illustrations to analyse how the odds are calculated to the various results. Note that most Australian casinos have roulette wheels with only one zero (no double zero) as in the first illustration. The second illustration on Resource Sheet 44 (which has a 0 and also a 00) is provided only to show the betting options, the given odds and where participants place their bets.
- Students should observe the range of multi-outcome bets that gamblers could choose. Bet B for example is a split bet where the gambler bets that either 13 or 14 will occur on the wheel. The odds are always calculated in the 'House's' favour. On this board, the real odds are 19 to 1 against either of those numbers occurring because there are 38 numbers (Numbers 1–36, 0 and 00). By offering only 17 to 1 on this result, the 'House' always has the edge over time.
- Have students study the other multi-outcome events such as the Line bet, the Corner bet, and the Column bet, Odds/Evens and Red/Black. The odds offered by the 'House' become smaller as the count of numbers involved in the bet increase. Even with the Red/Black option, the player has 18 chances of winning, but the 'House' has 20 chances (because of the 0 and 00).

- Students should also observe that when there is only a single zero, the player has a better chance of winning, but the odds are still with the 'House' to win over time. It has been calculated that a single zero still gives the 'House' a 2.7% edge of winning over time (having the 0 and the 00 gives the House a 5.2% edge).
- Then have the students investigate the probabilities associated with the games based around compound events and conditional probabilities. It may be helpful if they explore the calculations involved with smaller sets of numbers – such as the numbers 1 to 10 and the chances of predicting the first three numbers to be drawn out of a container.
 - o Have all of the students make their predictions by nominating three numbers. These should be noted on the board or in the students' maths pads.
 - o Discuss ways of conducting the experiment so that each of the 10 numbers has an equal chance of being drawn out.
 - o As the first number is drawn out, discuss its probability with the students – they should agree that the chances were 1 in 10 or $1/10$.
 - o Draw out the second number and work out its probability as 1 in 9 or $1/9$.
 - o Draw out the third number and note its probability as 1 in 8 (because there are only 8 numbers left to choose from).
- Imagine that the three numbers drawn out were 7, 2 and 4. The probability of drawing out the numbers in this order is $1/10 \times 1/9 \times 1/8$ or $1/720$.
- Then discuss with the students whether the order needed to be 7, 2 and 4 or whether any order would be okay. If any order would be acceptable, then these numbers could have been drawn out in 6 different ways (i.e. 724, 742, 472, 427, 247 and 274).
- This could have been calculated by saying that there are three options for the first number, two options for the second (once the first has been decided) and then only one option left for the third (or $3 \times 2 \times 1 = 6$).
- Therefore with six acceptable ways of arriving at these numbers, the probability can be determined as $6/720$ or $1/120$.
- The students should use this technique to work out the probabilities associated with a Gold Lotto draw which involves 45 numbers and six numbers initially to identify the top prize numbers.
- Students should calculate the probabilities as a 1 in 45 chance of selecting the first number correctly, one in 44 for the second number and so on.
- They would finish with a calculation like $1/45 \times 1/44 \times 1/43 \times 1/42 \times 1/41 \times 1/40$. This calculation says that selecting the correct six numbers in the correct order is a one in 5,864,443,200 chance.
- However, in Lotto the order of numbers is not critical, and there are 720 different ways of arriving at that set of six numbers ($6 \times 5 \times 4 \times 3 \times 2 \times 1 = 720$). So the chances of selecting the six numbers correctly is 720 in 5,864,443,200 and this can be written as one in 8,145,060.
- A standard entry has 12 games so if a person plays a standard entry, the chances are 12 in 8,145,060 or one in 678,755.
- Have the students analyse the conditions associated with the Powerball games and work out the chances of winning the top prize by listing out and calculating the probabilities.
- They can change the conditions and see what effect occurs to the probabilities of winning. They might create a game where there are only 40 numbers to choose from in each part of the game. How much would this change improve their chances of winning?

How does knowledge about theoretical probability and conditional probability assist me make informed decisions about the various forms of gambling?

Teaching considerations

- Teachers might propose to students that sometime in the future, they might be in a club where games such as Keno are being played by the patrons. Will they decide to play? Keno is easy to play, but do the players understand their chances of winning – or, more importantly, their chances of losing?
- Have the students look at the potential prizes that can be won. They should then use their knowledge of probability to work out their chances of winning. Teachers will need to support students' reasoning to work out some of the probabilities – especially related to the role of the 20 randomly generated numbers.
- The chances of winning should be compared to the prizes on offer. Students should discuss whether they would be prepared to risk their money – or save it to spend on other things.
- Resource Sheet 45 contains details about Keno copied from the Jupiters Casino website: (http://www.keno.jupiters.com.au/qld/external_frameset.htm.) The site has much more information about other games and prizes that can be won playing Keno. The Resource sheet concentrates on the Keno 10 number game and lists the prizes that can be won by matching four numbers (which is \$1) up to matching all 10 numbers (at the time of writing, this was a \$5 million jackpot).
- Students should find out how the game is played (from the numbers one to 80, a set of 20 different numbers are randomly picked and displayed).
- The students should select one of the games and seek the teacher's support to explore the probabilities. They should determine whether the game offers them value for the risk they are taking.
- Note: the following calculations about possible combinations may help with the probabilities for the Keno 10 number game:
 - The machine can generate $C(80, 20)$ different combinations of 20 numbers which is 3.53532×10 to power 18 (this number can be calculated by dividing $80!$ by $20!$ and then by $60!$);
 - A person could choose $C(80, 10)$ different combinations of 10 numbers which is 1.64649×10 to power 12 (this number can be calculated by dividing $80!$ by $10!$ and then by $70!$);
 - The probability that one of the person's combinations is within the machine's selection of 20 is $C(80, 10)$ divided by $C(80, 20)$ which is 4.65727×10 to power negative 7;
 - This means that the probability is a very small decimal fraction (0.000000465727) which translates to 1 in 2,147,181.
- Each student (or small group of students) should write a report which analyses the game they selected. The report should detail all of the calculations of the chances of winning and compare these to the prizes offered. Students might also consider the chances of losing in each game and include their evaluative comments about the game in the report.
- Have the students complete Resource Sheet 46 which contains the True/False quiz about the chance concepts studied within this module. Students should be prepared to justify their answers by referring to calculations they have made or by referring to data available in the Resource Sheets.

Answers to the True/False Quiz.

- a. **False** – this is one of the behaviours listed for problem gamblers, especially if it occurs regularly. If we decide to gamble, it should be part of our fun and entertainment and therefore be planned as part of the available budget.
- b. **False** – the chances of winning the first division in Powerball are six times less likely than Lotto.
- c. **True** – the overall odds of winning a prize with a standard entry (12 game panels) in the Saturday Gold Lotto are calculated as 1 in 18. This means that the chances of losing are 17 in 18 or about 94%.
- d. **True** – the numbers can be drawn out in any order.
- e. **False** – A person would need to fill out 8 145 060 different game panels to be sure of having an entry that won a share of the first division.
- f. **False** – the odds of 1 in 18 are overall odds and there is no guarantee that every set of 18 standard entries would have enough of the drawn numbers to win a prize.
- g. **False** – the odds of selecting all 10 numbers in a 10-number Keno game are about 1 in 8 900 000. Each game in Keno costs \$1 to play, so a prize of \$5 million does not match those odds.
- h. **True** – the odds of winning any prize in the Super 66 game are listed as one in 50. This means that only 2% of entries overall will win some kind of prize.

Useful websites

<http://indigo.ie/~gerryq/index.htm>

Gerry Quinn's website offers a range of games and includes an odds calculator for Lotto games.

<http://goldencasket.com>

The Golden Casket website provides a wealth of information about the legal gambling games played in Queensland. Information can also be found out about responsible gambling and historical results of each of the games.

<http://www.phm.gov.au/gambling/>

This website is entitled *Gambling: calculating the risk*. The website presents information researched by staff from the Powerhouse Museum, NSW teachers and Macquarie University. The information on this website was correct at the time of writing (2004). This website has been funded by the Casino Community Benefit Fund (NSW) as an information and education initiative aimed at raising awareness about problem gambling in the community. This website is designed to explain the mathematical principles which underpin gambling.

www.responsiblegambling.org/newscaan

Newscaan is an online newsletter which focuses on the issue of responsible gambling. It is funded by the Responsible Gambling Council (Ontario Province in Canada).

http://www.keno.jupiters.com.au/qld/external_frameset.htm

This website links to information provided by the Jupiters organisation which runs the three casinos in Queensland – Conrad Jupiters Casino in Broadbeach, Conrad Treasury Casino in Brisbane and Jupiters Casino in Townsville.

