Dragon Lesson Plan: Categorical Data

Curriculum Level 3

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Achievement Objectives

S3-1: Conduct investigations using the statistical enquiry cycle: gathering, sorting, and displaying multivariate category data … to answer questions; identifying patterns and trends in context, within and between data sets; communicating findings, using data displays.

Purpose

Investigating multivariate data using a set of dragon cards. Each dragon card provides several pieces of information about one dragon. Sorting and organising a set of dragon cards makes it possible to uncover information about the set.

Specific Learning Outcomes

- Sort information into categories.
- Display data in an appropriate format.
- Answer questions by sorting, organizing and arranging information.
- Make statements about the information with supporting evidence.

Description

This lesson focuses on sorting and organising data in various ways to uncover information about the dataset. In this case the dataset is the set of dragon cards for each group. The approach is different from starting with a question then collecting data to address it. The dragon cards allow students to consider issues needing more than one aspect to be considered at the same time.

Understanding the difference between individual data (one card) and group data (a set of cards) is central to the lesson. The goal is to have students make statements about the group in general. It also increases students' ability to accurately describe aspects of a dataset, including statistical vocabulary.

Required Resource Materials

- Class pack of dragon cards (allow 240 cards for a group of up to 32)
- Paper for students to record their results

Key Vocabulary

Categorical data, dataset, numerical data, statistical enquiry cycle.

Activity

This lesson follows the Statistical Enquiry Cycle (PPDAC) to investigate a situation using analysis of categorical data.

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Part 1 - Understanding the dataset

Purpose: Learn about the dataset, model a possible analysis.

Getting to know the dragon cards [Full class, 10 min]

Students already familiar with dragon cards, may still need to review meanings.
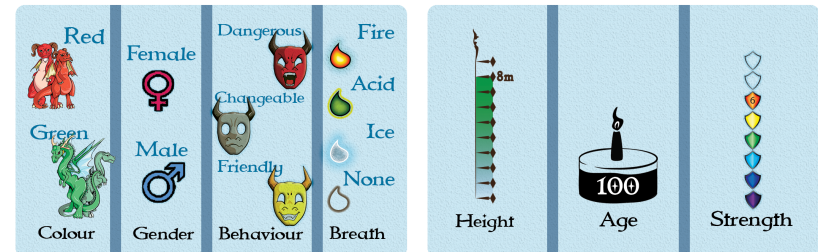
Give one card to each student. Ask them to work out what it tells them about their dragon. Let them compare with others. Ask them to guess what the things on the card could mean. As needed, provide a clear meaning of each element.

Explain to the students the difference between **categorical** and **numerical** data. Numerical data has a clear ordering (5m>3m) whereas categorical may not (male/female). Ask students to identify which data is categorical and which is numerical.

Tell the students you are going to organise them based on categorical data about their dragon. Get them to form groups based on their dragon's breath type, one group for dragons with fire breath, one for acid breath, one for ice breath and one for no special breath type.

Ask the students to compare cards in their group to see whether their group has more green dragons, more red dragons or about the same number of each.

Have the groups split by dragon colour, forming eight subgroups. Have them organised so they roughly form a 'statistical table' with red dragon groups on one side and green on the other. The four pairs of breath groups should align.

Ask the students if they can see any relationship between breath type and colour. There may or may not be an obvious difference depending on exactly which dragons the students have.

Part 2 - Categorical data

Purpose: Answering questions about categorical data and using PPDAC.

Dragon vaccination story [Full class, 5 min]

Statistical investigations require a purpose informed by the context.

Story

A virus is spreading though the population of South Pacific dragons. The virus, known as Pacific Draconian Flu, affects the delicate organs that dragons use to produce their dragon breath. Dragon breath is mainly used for displays when defending their territory. Dr Agon's team have a developed a vaccine for the flu. Reports show that dangerous dragons seem more likely to contract the virus.

The team need a vaccination plan for the dragons on the island. They will send out a number of missions targeting different groups of dragons. Dr Agon needs to know whether to target the red or green dragons of each group first to vaccinate as many dangerous dragons as early as possible. The dragons in each group need to be analysed before the missions leave.

Also, the vaccination teams will need to protect themselves against the types of dragon-breath they will encounter on their mission.

Posing questions - [Full class, 5 min]

A statistical investigation requires an investigative question. In this case the question is "Is the behaviour of our green dragons more likely to be dangerous than the behaviour of our red dragons?"

Exploring and comparing - [Groups, 20 min]

Organise the class into groups of four. Hand each group a set of 30 random cards. These are the dragons for a single mission. Have the students sort and organise the dragon cards to try to answer the investigative question and display findings. A group might split the cards into red and green dragons, with different students organising each colour.

Assist groups as needed. One way to help see things in the data and display findings is to tabulate the cards as shown in the picture.

The teacher moves around getting groups to explain and show what they have found. The teacher encourages students to add detail to their observations.

Results and conclusions - [Groups, 10 min]

As students develop displays of their findings using the cards they need to record the results on paper. This involves both recording numerical results and writing sentences about what they have found. Students could put the tallies or proportions into the appropriate cells of a table similar to the one below.

	Red dragons	Green dragons
Friendly	1/14	9/16
Changeable	3/14	5/16
Dangerous	10/14	2/16

The following provides a good framework for forming results. Use it either as steps to develop a meaningful conclusion (see the example below) or as a framework to question students and refine their thinking.

Observe: There are more dangerous red dragons.
Explain: More red dragon are dangerous than green dragons.
Evidence: The table shows more red dragons are dangerous than green dragons, 10 out of 14 for red compared to 2 out of 16 for green.
Context: The red dragons in our group should be vaccinated first as more red dragons are dangerous, 10 out of 14, compared to green dragons, 2 out of 16.

Where appropriate encourage students to think proportionally when the number in compared groups differs, e.g. 11 of 19 is a smaller proportion than 7 of 11.

Further investigation - [Groups, remaining time]

Students can then move on to investigate other similar questions. Let the groups guide their own investigations. Groups can explore questions directly related to the vaccination case as well as other questions they become interested in exploring.

Encourage students to look for interesting multi-dimensional things. This means looking at how different categories interact rather than simply counting the number in a single category. E.g., rather than seeing if there are more females than males, look to see if there is a link between gender and breath-type.

Finish up - [Full class, 5 min]

Get the students to report what they have discovered back to the class. Point out that different groups found different things about the same relationships as each group had different dragons.

Where to next? More ideas at shop.StatsLC.com – and do give us feedback as to what worked for you.

Teaching Notes for Dragon Card Lesson Plan: Categorical Data Curriculum Level 3

Overview

You can buy dragon cards and download more free lessons at shop.StatsLC.com

Achievement Objectives

S3-1: Conduct investigations using the statistical enquiry cycle: gathering, sorting, and displaying multivariate category … to answer questions; identifying patterns and trends in context, within and between data sets; communicating findings, using data displays.

Purpose

Investigating of multivariate data using a set of dragon cards. Each dragon card provides several pieces of information about one dragon. Sorting and organising a set of dragon cards makes it possible to uncover information about the set.

Specific Learning Outcomes

- Sort information into categories.
- Display data in an appropriate format.
- Answer questions by sorting, organizing and arranging information.
- Make sensible statements about the information with supporting evidence.

Outline

Part 1 – Understanding the dataset
  ➢ Getting to know the dragon cards [Full class, 10 min]
Part 2 – Categorical data
  ➢ Dragon vaccination story [Full class, 5 min]
  ➢ Posing questions - [Full class, 5 min]
  ➢ Exploring and comparing - [Groups, 20 min]
  ➢ Results and conclusions - [Groups, 10 min]
  ➢ Further investigation - [Groups, remaining time]
  ➢ Finish up - [Full class, 5 min]

Required Resource Materials

- Pack of dragon cards (allow 240 cards for a group of up to 32 students)
- Paper for students to record their results

Key Vocabulary

Categorical data, dataset, numerical data, statistical enquiry cycle.

Teacher Notes

Timings are approximate. Groups are likely to work through the phases at their own pace.

The statistics strand of the New Zealand mathematics curriculum is made up of three threads: Statistical Investigation, Statistical Literacy and Probability at all curriculum levels. This lesson is a part of the Statistical Investigation thread. The Statistical Enquiry Cycle underlies that thread.

The Statistical Enquiry Cycle is also called the PPDAC cycle. The steps in the PPDAC cycle are: Problem, Plan, Data, Analysis and Conclusion.

Part 1 - Understanding the data set
Getting to know the dragon cards [Full class, 10 min]

The third phase of the Statistical Enquiry Cycle is "Data". When an existing data set (in this case, the group's set of dragon cards) is being used, the investigator needs to become familiar with the data, to understand what it represents, includes and what the limitations of the data are. This understanding of the data set is used to inform the initial Problem and Plan phases of the Statistical Enquiry Cycle.

As well as being able to decode all of the information on the Dragon Cards, students should start becoming familiar with the symbols and categories.

The activity in this part of the lesson also models a possible analysis method. This can help to scaffold the analysis in the later part of the lesson.

Another option here is to get the students to try to find another student (or students) with four things or more on their cards that match. When they find a match they should hold up their hands with fingers showing how many things match.

Part 2 - Categorical data
Dragon vaccination story [Full class, 5 min]

A statistical investigation is more than just the analysis. It is important to have a context, which will give the investigation its purpose. This will inform the statistical questions to ask, the appropriate analyses and give meaning to the conclusions. In a statistical investigation (or lesson) it should be easy to answer the "why are we doing this" questions.

The story is intended to provide context and purpose. It is an important part of the lesson.

Posing questions - [Full class, 5 min]

Best practice for investigative questions is to structure the question so that the analysis of the investigation is self-evident.

The investigative question is "Is the behaviour of our green dragons more likely to be dangerous than the behaviour of our red dragons?"

Here, the key element, behaviour, is at the very front of the question. The two populations to compare are clear: behaviour of our green dragons and behaviour of our red dragons. The comparison "more likely to be dangerous" suggests comparing the proportions of dangerous dragons in the two groups. At this level the questions are focussed on the group's set of dragons by use of "our".

It is useful for the teacher to model this best practice but, at this stage, it is fine for students to pose less clear questions e.g., "Are more red dragons dangerous?"

Exploring and comparing - [Groups, 20 min]

Let students organise the data in ways that make sense to them. This lets students either discover a good way to organise the data or see the advantages of the tabular organisation when they see it.

Randomly allocated cards can lead to quite different results from different groups, e.g., one group may have very few red dragons. Depending on your students and your confidence you might find it useful to 'stack' the decks prior to class, so that each group gets similar results, so that certain groups get similar numbers of red and green dragons, or so that you know the expected results. It is important that all groups do **not** get the same result.

Results and conclusions - [Groups, 10 min]

Recording results is important. This provides the evidence from the statistical investigation. Results are not conclusions. In this case, the comments on the results form the conclusions.

Don't expect students to be able to use the framework given without being taught how to use it. Use it to encourage students to improve their sentences to the next level. For example, you might ask: "What evidence do you have that there are more dangerous red dragons?" or, "What does that mean for the vaccinations? Should the red or green dragons be vaccinated first?"

Conclusions should focus on the outcomes for the students' own group. Inference (inferring properties of the whole population of 240 dragon cards based on what students find from their 30 dragons) comes at a higher level of statistical understanding. As appropriate, the teacher might ask questions to get students thinking about and discussing that concept.

Students can be eager to get onto another investigation of the Dragon Cards. Before allowing that, make sure that they have recorded a concluding statement. Preferably the concluding statement should be meaningful to the context, that is, advice about the vaccinations.

Since the groups will generally have different results, minor counting or sorting errors can be ignored. Of course accuracy is important, however, the focus of this lesson is on the statistical investigation not counting and sorting.

Further investigation - [Groups, any remaining time]

This allows students who finish their investigation faster to practice the Problem, Analysis and Conclusions phases. Students can be eager to get to the analysis phase so, where appropriate, get them to pose, and possibly write down, their question first.

The questions should be driven by the previous investigation. That doesn't mean the questions need to directly address the vaccination scenario. The question could, instead, arise directly from exploring the cards. Student questions do not need to follow best practice. It is also fine for students to refine or adapt their questions during the analysis.

Some possible categorical questions:

Questions directly relevant to the vaccination scenario:
- Is the behaviour of male dragons more likely to be dangerous than the behaviour of female dragons?
- Is the behaviour of red female dragons more likely to be dangerous than the behaviour of red male dragons, green female or green male dragons?
- Are the breath-types of green dragons in similar proportion to the breath-types of red dragons?

Other questions:
- Is the gender of red dragons more likely to be male than the gender of green dragons?
- Are the breath-types of friendly dragons in similar proportion to the breath-types of dangerous and unpredictable dragons?

Finish up - [Full class, 5 min]

Note the concepts of sampling from a population and inference to the population are at level 5 in the NZ Curriculum. At level 3 we are concerned with descriptive statistics, but students may gain an idea that different samples will give slightly different results. This will help for when the concepts of sampling and inference are introduced.

Further activities and resources are provided on http://shop.StatsLC.com
Last updated: 3 June, 2016

Dragon Lesson Plan: Numerical Data

Curriculum Level 3

You can order Dragon Cards and download other free lessons at shop.StatsLC.com

Achievement Objectives

S3-1: Conduct investigations using the statistical enquiry cycle: gathering, sorting, and displaying multivariate category and whole-number data … to answer questions; identifying patterns and trends in context, within and between data sets; communicating findings, using data displays.

Purpose

Investigating multivariate data using a set of dragon cards. Each dragon card provides several pieces of information about one dragon. Sorting and organising a set of dragon cards makes it possible to uncover information about the set.

Specific Learning Outcomes

- Sort information into categories.
- Choose an appropriate data display.
- Display data in an appropriate format.
- Answer questions by sorting, organizing and arranging information.
- Make sensible statements about the information with supporting evidence.

Description

This lesson focuses on sorting and organising data in various ways to uncover information about the dataset. In this case the dataset is the set of dragon cards for each group. The approach is different from starting with a question then collecting data to address it. The dragon cards allow students to consider issues needing more than one aspect to be considered at the same time.

Understanding the difference between individual data and group data is central to the lesson. The goal is to have students make statements about the group in general. It also seeks to increase students' ability to accurately describe aspects of a dataset, including developing statistical vocabulary.

Required Resource Materials

- Class pack of dragon cards (allow 240 cards for a group of up to 32)
- Paper for students to record their results

Key Vocabulary

Categorical data, dataset, evidence, multi-dimensional, multivariate data, numerical data, statistical enquiry cycle, tends to.

Activity

This session follows the Statistical Enquiry Cycle (PPDAC) to investigate a situation using analysis of numerical data.
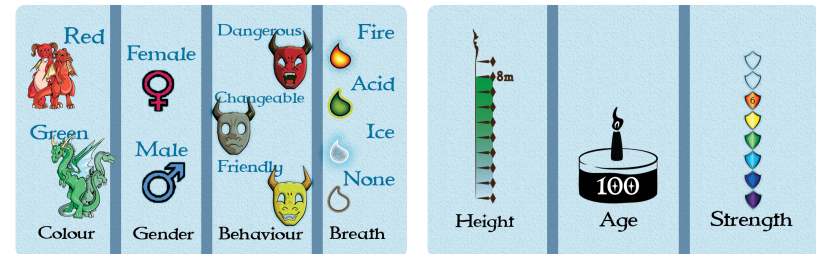
Part 1 - Understanding the dataset

Purpose: Learn about the dataset, model a possible analysis.

Getting to know the dragon cards [Full class, 10 min]

Students already familiar with dragon cards, may still need to review meanings.

Give one card to each student. Ask them to work out what it tells them about their dragon. They may wish to compare with others. Ask the class to guess what the things on the card could mean. As needed on any element, provide a clear meaning.

Explain to the students the difference between **categorical** and **numerical** data. Numerical data has a clear ordering (5m>3m) whereas categorical may not (male/female). Ask students to identify which data is categorical and which is numerical.

Tell the students you are going to organise them based on numerical data about their dragon. Get them to form lines based on their dragon's strength. One line for strength 1, one for strength 2 etc. Make sure the lines run next to each other in order of strength, from strength 1 on the left to strength 8 on the right.

The students form a 'physical graph' showing the stength of their dragons. Point out which strengths are most common and which are least common.

Get the students holding a female dragon to raise their hand. Then to raise their hand if the have a male dragon. Ask them to look to see whether male or female dragons tend to be stronger. There may or may not be an obvious difference depending on exactly which dragons the students have.

Part 2 - Numerical data

Purpose: Answering questions about numerical data using PPDAC.

Vaccination dosage story [Full class, 5 min]

Statistical investigations require a purpose informed by the context.

> **Story**
>
> A virus called Pacific Draconian Flu is spreading though the population of South Pacific dragons. Scientists working with Dr Agon have a developed a vaccine for the flu. The vaccine dosage depends on the size (height) of the dragon.
>
> Teams will go on vaccination missions targeting different small groups of dragons. Dr Agon needs to know the range of dosage sizes to send with each team. Should a team take equal numbers of each dosage size? Or, should they take more dosages suitable for middle-sized dragons than for smaller dragons? The dragons in each group need to be analysed before the missions leave.

Posing questions - [Groups, 10 min]

Organise the class into groups of four. Hand each group a set of 30 random cards. These are the dragons for a single mission. Get them to determine an investigative question based on the story. They may find it easier to pose a comparative question, splitting the dragons into groups based on a category, say colour. For example, "Do the heights of our green dragons tend to be taller than the heights of our red dragons?" Questions based a single group are also fine, e.g., "Do the heights of our dragons tend to be similar?" Help groups that are having difficulty coming up with a question.

Exploring and comparing - [Groups, 15 min]

Have the groups organise the dragon cards to try to answer their question and display their findings. They may split the cards into sets, with different students organising each set.

Ordering dragon cards in a line, by height say, makes it difficult to see how many dragons have the same height. This can be addressed by piling cards with the same height or, better, arranging them perpendicularly to the ordered line. This leads to a bar graph using cards to form the bars, as shown in the photograph. Spaces should be left for missing values.

Graphs can be matched in different ways for easy comparison, for example:

Side-by-side   Above-below   Reflected

Results and conclusions - [Groups, 10 min]

As students develop displays of their findings they need to record results. This involves writing sentences about what they have found. They might also record results by taking a photograph or sketching their graph. The following provides a good framework for forming sentences. Students can use it as steps (as below) or use it to question students to help refine their thinking.

Observe: The green dragons are taller.
Explain: Our green dragons tend to be taller than our red dragons.
Evidence: The graph shows our green dragons tend to be taller than our red dragons as there are more green dragons (6) than red (1) in the larger height categories (6-9m).
Context: Higher dosages should be taken when vaccinating the green dragons in our group as they tend to be taller than the red dragons.

Further investigation - [Groups, remaining time]

Students can move on to investigate other similar questions. Let the groups guide their own investigations. Groups can explore questions directly related to the vaccination case as well as other questions they become interested in.

Encourage the students to look for multi-dimensional things. They could compare numerical data within different subgroups rather than a distribution for the whole group. For example, comparing strength of males versus females. Students can also look at relationships between different numerical variables – height and strength, say. For this they might create a physical scatterplot.

Finish up - [Full class, 5 min]

Get the students to report what they have discovered back to the class. Point out that different groups found different things about the same relationships as each group had different dragons. This is quite different from much of mathematics, where there are clear, single right and wrong answers.

Where to next? More ideas at shop.StatsLC.com – and do give us feedback as to what worked for you.

3 June 2016

Teaching Notes for
Dragon Card Lesson Plan: Numerical Data Curriculum Level 3

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Overview

Achievement Objectives

S3-1: Conduct investigations using the statistical enquiry cycle: gathering, sorting, and displaying multivariate category and whole-number data … to answer questions; identifying patterns and trends in context, within and between data sets; communicating findings, using data displays.

Purpose

Investigating multivariate data using a set of dragon cards. Each dragon card provides several pieces of information about one dragon. Sorting and organising a set of dragon cards makes it possible to uncover information about the set.

Specific Learning Outcomes

- Sort information into categories.
- Display data in an appropriate format.
- Answer questions by sorting, organizing and arranging information.
- Make sensible statements about the information with supporting evidence.

Outline

Part 1 – Understanding the dataset
> Getting to know the dragon cards [Full class, 10 min]

Part 2 – Numerical data
> Vaccination dosage story [Full class, 5 min]
> Posing questions - [Groups, 10 min]
> Exploring and comparing - [Groups, 15 min]
> Results and conclusions - [Groups, 10 min]
> Further investigation - [Groups, remaining time]
> Finish up - [Full class, 5 min]

Required Resource Materials

- Pack of dragon cards (allow 240 cards for a group of up 32 students)
- Paper for students to record their results

Key Vocabulary

Categorical data, dataset, evidence, multi-dimensional, multivariate data, numerical data, statistical enquiry cycle, tends to.

Teacher Notes

Timings are approximate. Groups are likely to work through the phases at their own pace.

The statistics strand of the New Zealand mathematics curriculum is made up of three threads: Statistical Investigation, Statistical Literacy and Probability at all curriculum levels. This lesson is a part of the Statistical Investigation thread. The Statistical Enquiry Cycle underlies that thread.

The Statistical Enquiry Cycle is also called the PPDAC cycle. The steps in the PPDAC cycle are: Problem, Plan, Data, Analysis and Conclusion.

Part 1 - Understanding the data set
Getting to know the dragon cards [Full class, 10 min]

The third phase of the Statistical Enquiry Cycle is "Data". When an existing data set (in this case, the group's set of dragon cards) is being used, the investigator needs to become familiar with the data, to understand what it represents, includes and what the limitations of the data are. This understanding of the data set is used to inform the initial Problem and Plan phases of the Statistical Enquiry Cycle.

As well as being able to decode all of the information on the Dragon Cards, students should start becoming familiar with the symbols and categories.

The activity in this part of the lesson also models a possible analysis method. This can help to scaffold the analysis in the later part of the lesson.

Another option here is to get the students to try to find another student (or students) with four things or more on their cards that match. When they find a match they should hold up their hands with fingers showing how many things match.

Part 2 - Numerical data
Vaccination dosage story [Full class, 5 min]

A statistical investigation is more than just the analysis. It is important to have a context, which will give the investigation its purpose. This will inform the statistical questions to ask, the appropriate analyses and give meaning to the conclusions. In a statistical investigation (or lesson) it should be easy to answer the "why are we doing this" questions.

The story is intended to provide context and purpose. It is an important part of the lesson.

Posing questions - [Full class, 5 min]

The question should allow the students to use the dragon cards they have to help Dr Agon in the story. That is, it should link the story to the analysis. It is fine for different groups to have different questions. It can be useful to have the students write down their question that ensures it is more focussed than, for example, "We want to know about heights."

Some example questions are:
Do the heights of our green dragons tend to be taller than the heights of our red dragons?
Do the heights of our female dragons tend to be taller than the heights of our male dragons?
Do the heights of our dragons tend to be similar?

If students are not sure of the types of questions to ask, give an example and let students choose to use that example or come up with their own.

Best practice for investigative questions is to structure the question to allow the analysis of the investigation to be self-evident. For the first example question above, the key element, height, is at the very front of the question. The two populations to compare are clear: the heights of our green dragons and the heights of our red dragons. The comparison "tend to be taller" suggests the heights of most green dragons are expected to be bigger than the heights of most red dragons but with some red dragons possibly taller than some green dragons. At this level the questions are focussed on the group's set of dragons by use of "our".

It is useful for the teacher to model this best practice but, at this stage, it is fine for students to pose less clear questions e.g., "Are the red dragons taller?" It is also fine for students to refine, adapt or change their questions during the analysis.

Exploring and comparing - [Groups, 20 min]

Let students organise the data in ways that make sense to them. This lets them discover a good way to organise the data or see the advantages of a physical bar graph when they see it.

Randomly allocated cards can lead to quite different results from different groups, e.g., one group may have very few red dragons. Depending on your students and your confidence you might find it useful to 'stack' the decks prior to class, so that each group gets similar results, so that certain groups get similar numbers of red and green dragons, or so that you know the expected results. It is important that all groups do **not** get the same result.

Results and conclusions - [Groups, 10 min]

While recording results is important, do not worry about recording the graphs produced. Re-drawing the physical graphs is a useful way of recording results but not a good use of the student's time. You might, however, choose to take photos of the student's work.

The main focus for this part of the lesson should be on developing and recording sentences drawing conclusions.

Don't expect students to be able to use the framework given without being taught how to use it. Use it to encourage students to improve their sentences to the next level. For example, you might ask: "What evidence do you have that your red dragons are taller than your green dragons?" or, "What does that mean for the vaccination dosages? Should the team take larger or smaller dosages for the red dragons compared to the green?"

Students can be eager to get onto another investigation of the dragon cards. Before allowing that, make sure that they have recorded a concluding statement. Preferably the concluding statement should be meaningful to the context, that is, advice about the vaccinations.

Since the groups will generally have different results, minor counting or sorting errors can be ignored. Of course accuracy is important, however, the focus of this lesson is on the statistical investigation not counting and sorting.

Further investigation - [Groups, any remaining time]

This allows students who finish their investigation faster to practice the Problem, Analysis and Conclusions phases. Students can be eager to get to the analysis phase so, where appropriate, get them to pose, and possibly write down, their question first.

The questions should be driven by the previous investigation. That doesn't mean the questions need to directly address the vaccination dosage scenario. The question could, instead, arise directly from exploring the cards.

Some possible numerical questions:

Questions directly relevant to the vaccination dosage scenario:
• Do the heights of our female dragons tend to be taller than the heights of our male dragons?
• Do the heights of our female green dragons tend to be taller than the heights of our female red dragons, the heights of our male green dragons and the heights of our male red dragons?
• Do the heights of our dangerous dragons tend to be taller than the heights of our unpredictable dragons, and the heights of our friendly dragons?

Other questions:
• Does the strength of our green dragons tend to be larger than the strength of our red dragons?
• Does the age of our green dragons tend to be larger than the age of our red dragons?
• Do the heights of our dragons tend to get larger as the dragons get older?

Age is a continuous variable better suited to display as a histogram than a bar chart. Histograms bring their own set of challenges, for example, how big to make the bin sizes. Students may wish to wrestle with this challenge if they are ready for it.

Comparing two numerical variables can be done with a physical scatterplot. Here students lay out one variable in horizontally in proportion to its value, as in a bar chart. The other variable is

simultaneously laid out in a similar manner but vertically. In both directions spaces are left for missing values. Students may wish to wrestle with this challenge if they are ready for it.

Finish up - [Full class, 5 min]

Note the concepts of sampling from a population and inference to the population are at level 5 in the NZ Curriculum. At level 3 we are concerned with descriptive statistics, but students may gain an idea that different samples will give slightly different results. This will help for when the concepts of sampling and inference are introduced.

Further activities and resources are provided on http://shop.StatsLC.com
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Rich Tasks using Dragon Cards

Rich Task 1: TV Documentary

The dragon cards you have are all of the dragons on one island. You are producing a TV documentary of red and green dragons on the island. You will need to tell the audience how they are different and how they are the same.

Teacher details

The students could be in groups with about 30 cards per group. Get the students to present a part of their documentary to the rest of the class.

Rich Task 2: Developing dragon card games

Create a game with dragon cards which practices maths skills. Is the game fun? What maths skills does it practice? Is the game fair? Is the game easy or hard? How long does it take to play? Is it suitable for younger students?

Teacher details

Get the students to test out their games. They could teach their game to another group (or the class) and get feedback. Get the groups to use the feedback to improve their game.

The groups could collect relevant statistics about their game. Such as how often the first player wins or what scores are achieved. They can use that to address the questions about the fairness of the game, how long it takes and whether it is easy or hard.

Rich Task 3: Odd one out

Work out which of the dragon cards you have is the odd-one-out. How many of your cards can you make the odd-one-out by using different criteria? Compare your odd-one-out and criteria with another student. Do your criteria give an odd-one-out for their set of cards?

Teacher details

Give the students 8 cards each. Get pairs to students to explain which card is the odd-one-out from their set and why. Get the students to count how many of their cards can be the odd-one-out using different criteria. Can they make all of their cards the odd-one-out by using different criteria?

Rich Task 4: Same and different

Make pairs of dragons with one, two or three things the same. What is the most number of things the same you can get? Try the same with more cards. Work out scores based on the number of cards and the number of things matching. What is the highest score you can get from 5 cards?

Teacher details

Encourage the students to think up further activities based on matching and difference.

Rich Task 5: Dragon shelters

The dragon cards you have are all of the dragons on one island. Dragon shelters are needed to keep the dragons safe. The layout of shelters, the materials used and the number needs to be based on the types of dragons, their size, strength, behaviour and breath-type. Find out about your dragons and plan appropriate shelters.

Teacher details

Get the students to draw up plans of their shelters. The plans will need to include notes about things like building materials and why they have chosen the layout they have.

Give the students free rein on the needs of the dragons. For example, they may need to think of a material that can withstand the acid breath. The shelter sizes will depend on the dragon heights. The materials needed may depend on the dragon strengths. There could be an advantage to separating males and females. Friendly dragons might need shelters in clusters while shelters for dangerous dragons may need to be further apart. You could let individual students make up their own information or continually add to a common class list.

An extension is to include cost information about the materials and shelters. For example, have different costs for shelters made of concrete or wood and suitable for different behaviours. Get the students to work out the cost of their plan. Can they save money by adjusting their plan? You could add different levels of complexity here, such as the cost of feeding.

Rich Task 6: Dragon game park

You are setting up a game park for dragons. The dragon cards you have represent the dragons in your game park. Your park needs a range of dragon types for the visitors to see.

The space needed for a dragon is different based on its colour and behaviour. Your teacher has the details. Work out how much space your set of dragons needs and the cost of purchasing this space. Dragons in your game park also need feeding. Work out the cost of feeding your dragons.

You can also trade dragons with other students to adjust your range of dragons and to reduce the cost of space and feeding.

Teacher details

Provide information for the students on the cost of purchasing space and the amount of space needed by different types of dragons. Start with a reasonably simple set of data. Later you might add some complications – for example a breeding pair might need less (or more) space than the two individuals, in which case you need to determine how breeding pairs are determined.

Provide the feeding costs after students have worked out the purchasing cost. You may want to add additional costs as well. Give more complicated cost data to students as appropriate. Income could depend on the diversity of dragons, for example based on the strength of their strongest dragon and the number of colour-breath combinations.
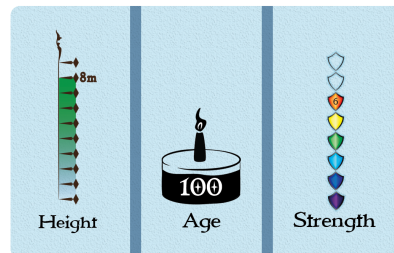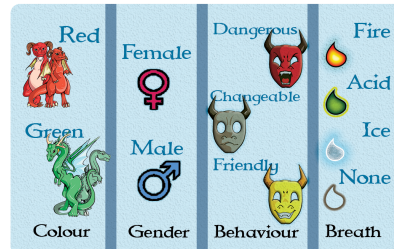
Dragon Card Games

Speed sorting

- Players: 2 to 4, or more players with a larger pack.
- Teaches: ordering and sorting
- Equipment: Attribute cards, dragon cards (40 to 240 depending on the number of players)
- Difficulty: Straight-forward

Preparation

Choose which attributes you will be ordering or sorting on, and make a facedown pile of those attribute cards.

Possibilities are:

- Sorting:
    o Colour,
    o Gender,
    o Behaviour,
    o Breath.
- Ordering:
    o Height,
    o Age,
    o Strength,
    o Name Order (alphabetical),
    o Horns (count them from the picture).

Each player is given three dragon cards. There are placed face up in front of them on the table in a pile.

Aim

To earn ten dragon cards by being the fastest to sort or order cards.

Game play

First player turns over an attribute card and reads aloud the attribute.

All players race to put their cards in piles or in an ordered row according to the attribute. For example if the attribute is gender, they put all their females in one pile and all the males in another pile. If the attribute is strength, they order them by increasing (or decreasing) strength. As soon as they are finished they place a hand on the attribute card.

Check for correctness. If the first player finished is correct, give that player another dragon card. If not correct, take one away (to a minimum of three cards).

The winner of that round turns over the next attribute card and reads aloud the attribute.

Players who are fast, get more cards, which may slow them down.

When the pile of attribute cards is used up, shuffle them and start again.

Ending the game

The game ends when any player gets a tenth dragon card.

The winner is the first player to get ten dragons.

Other ideas

This game has worked well when played with a whole class. Extra cards can be awarded for the first three (say) finishers.

For a group with a range of ages, younger players could stop when they reach their age. Six cards for 6 year olds, etc.
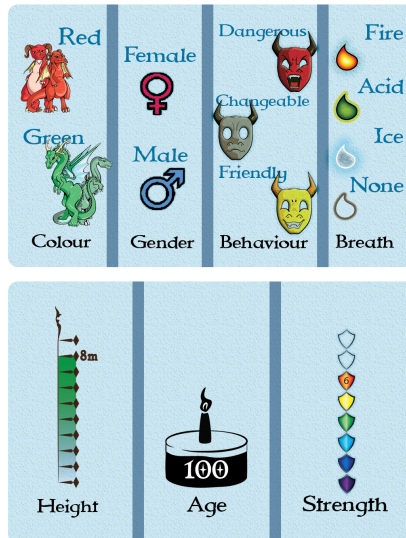
Dragon Twins

- Players: 2 to 4.
- Teaches: Finding things that are the same
- Equipment: Attribute cards, dragon cards
- Difficulty: Straight-forward, some strategy

Preparation

Place the dragon cards face down in a pile in the middle of the table.

Choose the following 12 attribute cards and spread them face up in the middle of the table. (You can use just some of these if desired.)

- o Gender
- o Colour
- o Colour and Gender
- o Behaviour
- o Breath
- o Breath and Behaviour
- o Name Length
- o Strength
- o Height
- o Age Century
- o Horns
- o All Different

Aim

To get the most attribute cards.

Game play

The first player draws and turns over two dragon cards. The player looks at what things the two dragons have in common and chooses an attribute card that applies. (There may be several applicable.) The player may take an attribute card from the pool in the middle, or they may take one from one of the other players.

When none of the attribute cards used would appy (even the ones in front of the current player), the player can take the All Different attribute card.

Place the attribute card taken (if any) in front of them, and place the dragon cards in the discard pile.

Players take turns to turn over two dragon cards, and choose which attribute card to take. Sometimes it may not be possible to take another attribute card, if the player already has the applicable one.

Ending the game

The game ends when there are no attribute cards in the pool and one player (the winner) has more cards than anyone else. If the attribute cards in the pool run out but no one player has the most cards, play continues until there is an outright winner.

Game options

The All Different attribute card can make the game more difficult. The Name Length attribute card can also be tricky to check. You may choose not to include these cards.

Solitaire version

The player sees how few "wasted" pairs of dragons they need to gain all the attribute cards.

Teams of three (Solitaire)

- Players: 1 (with a variation for more than 1)
- Teaches: Addition, subtraction, more or less, categorisation
- Equipment: Dragon cards
- Difficulty: Straight-forward, some strategy

Preparation

Place the dragon cards in a face down pile.

Aim

To get the most powerful set of 12 dragons according to strength

Game play

From the face down stack, deal off cards one at a time and place in rows of uo to three according to colour and gender (called type)

When you get more than three of the same type, the new dragon must go on top of another dragon of the same type (trying to maximise the strength)

Example:

Turns 1 to 9

Red Male, strength: 6	Red Male, strength: 2	Red Male, strength: 5
Green Male, strength: 4	Green Male, strength: 1	
Green Female, strength: 5		
Red Female, strength: 6	Red Female, strength 6	Red Female, strength 6

Turn 10: Red male, strength 6. This goes in the Red Male team, and the best choice is to put it on top of the Red Male Strength 2.

Red Male, strength: 6	Red Male, strength: 6	Red Male, strength: 5
Green Male, strength: 4	Green Male, strength: 1	
Green Female, strength: 5		
Red Female, strength: 6	Red Female, strength 6	Red Female, strength 6

Turn 11: Red male, strength 4. We don't really want this one as it weakens the team, but we have to add it to the Red Male team, so we put it on the Red Male, strength 5, to minimise the loss in strength.

Red Male, strength: 6	Red Male, strength: 6	Red Male, strength: 4
Green Male, strength: 4	Green Male, strength: 1	
Green Female, strength: 5		
Red Female, strength: 6	Red Female, strength 6	Red Female, strength 6

Ending the game

The game stops when all rows have three dragons showing.

Scoring - add up the strength. See what is the highest score you can get.

Variations

This can be played as a competition between players to see who gets the strongest team.

You can use different team criteria, such as behaviour or breath.

You can use different scoring criteria, such as weakest, oldest, youngest, shortest, tallest etc.

You can place each dragon in a specific slot, but you can't move it once it is there. The strengths must increase from left to right. If it is possible to place a card, you must do so.

Dragon Cards Activity: Gender-Behaviour

Equipment

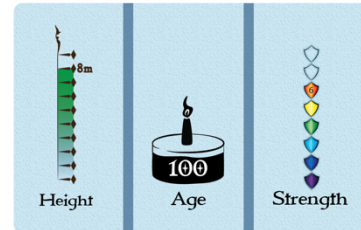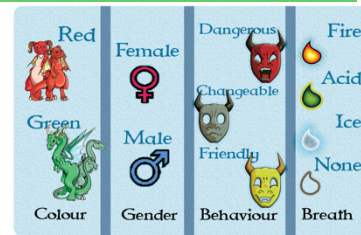- About 30 dragon cards
- This worksheet

Investigative question

Are male dragons more likely to be dangerous than female dragons?

Instructions

Dragons are male ♂ : 🐉🐉 or female ♀ : 🐉🐉

Behaviour is friendly 😊 changeable 😐 or dangerous 😈

1. Count your cards.
   Write the number on the activity sheet.

2. Arrange your cards in the table.

   Put males in the first column.
   Put females in the second column.

   The row matches the behaviour.

Activity
Number of cards: _____30_____

3. Count the cards in each box.
   Write the number.

Male ♂:	Female ♀:
Friendly 5	6

4. Count the male dragons. Write the total.
   Count the female dragons. Write the total.

Total | 13

5. Fill in the sentences under the table
   with the correct numbers.

Results
There are __8__ dangerous female dragons out of ____ fema

6. Write your own results sentence similar to those given.

7. Circle the correct conclusion.

8. Write your own conclusion sentence about what you found.

Activity Sheet: Gender-Behaviour Analysis

Number of cards: _____

Male ♂ :   Female ♀ :

	Male	Female
Friendly		
Changeable		
Dangerous		
Total		

Results

There are ____ dangerous female dragons out of ____ female dragons.

There are ____ dangerous male dragons out of ____ male dragons.

_____

Conclusion

There are more dangerous female dragons than dangerous male dragons.

There are more dangerous male dragons than dangerous female dragons.

There are just as many dangerous female dragons as dangerous male dragons.

_____

Activity Sheet: Colour-Breath Analysis

Investigative Question: Is the distribution of red dragon breath type different from the distribution of green dragon breath type?

Number of cards: _____

	Red	Green
Fire		
Ice		
Acid		
None		
Total		

Results

There are _____ red dragons with fire breath out of _____ red dragons.

The most common breath type for green dragons is _____.

My sentence: _____

Conclusion

Red dragons have more-or-less the same distribution of breath types as green dragons.

Red dragons have a different distribution of breath types than green dragons.

is the same colour as

is shorter than

is younger than

has a longer name than

Statistics
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Can you place dragon cards to make the statements correct?

has the same breath as

has a different behaviour to

is stronger than

has the same gender as

Dragon Lesson Plan: Sampling

Curriculum Level 5
Achievement Objectives

S5-1: … using the statistical enquiry cycle:

- using multiple displays, and re-categorising data to find patterns, variations, relationships, and trends in multivariate data sets
- comparing sample distributions visually, using measures of centre, spread, and proportion
- presenting … findings.

> You can order Dragon Cards and download other free lessons at shop.StatsLC.com

Purpose

This lesson allows the investigation of multivariate data using a sample of dragon cards to infer properties of the population of cards.

Specific Learning Outcomes

- Compare sample distributions visually.
- Choose an appropriate sampling process.
- Infer properties of a population by sorting and analysing a sample.
- Make sensible statements about the information with supporting evidence.

Description

This lesson focuses on analysing data from samples to infer properties about a population. It allows students to appreciate why sampling can be necessary and how it can be used for inference. In this case the population is a set of 240 dragon cards that provide information about individual dragons. The number of cards is too big to make physically analysing the whole population practical.

As different students analyse different samples students can appreciate the variation across samples but also the general consistency of results. A sampling distribution can be formed from the class results. They can also combine results to see the effects of larger samples.

Required Resource Materials

- One or more class packs of dragon cards
- Some way for students to record their results

Key Vocabulary

Sample, population, inference, median, inter-quartile, box-plot, tends to.

Activity

This session follows the Statistical Enquiry Cycle (PPDAC) to investigate a situation using sampling for inference. Before beginning this lesson it is important students have a common understanding about the data presented on the dragon cards.

Robust shelters story

Statistical investigations require a purpose informed by the context.
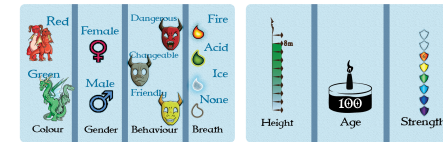
Case

Female and male dragons over-winter separately. A recent cyclone destroyed the shelter in their usual over-wintering locations on an island in the Pacific. A team from an environmental organisation (led by Dr Nic) plans to build artificial shelters for the dragons.

Making shelters robust enough for the strongest dragons is costly. The team wonder if it will be cost-effective to make less robust shelters for the female dragons than for the male ones.

Testing dragon strength is time consuming and the team does not have the resources to test the whole dragon population.

Investigative question and planning [10-15 min]

Part of the Problem phase of the PPDAC process is to determine an investigative question. For this lesson we will use:

> "Do the strengths of female dragons tend to be weaker than the strengths of male dragons?"

The Plan phase of the PPDAC process requires planning how to address the investigative question. Put the students into groups and ask each group to come up with a plan to share with the class. Share the plans, discuss the issues that arise from the plans and develop a common class plan.

The class plan should include: how many dragons to analyse, how the sample will be taken, and what analyses to perform.

The case indicates that the team cannot test the strength of all dragons. This means that the analysis can only be applied to some of the dragons. Some questions that can be discussed with the class: Can the results from only some dragons be used to discover things about all of the dragons? How well will the results from some dragons match the result for all dragons?

The class plan might include some details on the way the sample is taken, for example it might be stratified with equal numbers of female and male dragons. For this lesson 30 cards is a good sample size to use. The number of cards and the way samples are taken may be limited by the total number of dragon cards and the number of groups you have. It is best not to use all the cards in samples.

Analysis [15-20 min]

Give each group a sample of dragon cards to analyse according to your class plan.

A good analysis for this lesson is to create a pair of physical bar graphs, one above the other with the strength values aligning. The analysis should include creating a pair of box-plots too. Both pairs of graphs will compare strength for male and female dragons. The picture shows an example of the bar charts and box-plots.

Box-plots can be made on loose paper and of a size consistent with the bar charts (scissors and tape may be needed to make the charts wide enough). The box-plots can be laid just above or below the corresponding bar chart.

To record the graphs they could be sketched, photographed, or a graphing application used.

Results and conclusions [10 min]

As students develop displays of their findings they need to record results. This involves a written description of what they find as well as choosing one or more data displays to support their statements. The recorded results can be about the sample or can make inferences to the population.

Each group will need to make a judgement about the investigative question, in particular making an inference to the population. Depending on their samples and their opinions, different groups might make different judgements. One rule of thumb to use for curriculum level 5 is that if one group has a median outside the inter-quartile box of the other, this suggests that the groups of dragons are different in the population.

OSEM provides a good framework for forming results and conclusions. An example is given below.

For the sample shown in the picture, the investigative question does not appear to hold. Actually the sample suggests the opposite.

Obvious: The female dragons tend to be *stronger* than the male dragons.
Specify: The results suggest that the female dragons in the population tend to be stronger than the male dragons in the population. The effect in the sample suggests female dragons tend to be stronger than males in the population.
Evidence: While there are some male dragons stronger than some female dragons, the strongest 10/17 of female dragons in the sample are stronger than the weakest 11/13 of male dragons in the sample.
Meaning: Shelters for the female dragons should generally be made more robust than those for the male dragons.

Discussion [10 min]

Have each group report their findings and conclusions to the class. Discuss the variation between the results and the variation between the conclusions of the groups. Generally the results should all differ but generally be similar. Point out that the conclusions will, in part, depend on chance – the exact sample analysed – and different groups can legitimately come to different conclusions.

Discuss whether the conclusions are definitely correct and how you might find out whether they are. Ask the class to speculate whether combining each group's sample into a single giant sample will improve the conclusions.

Where to next? More ideas at shop.StatsLC.com – and do give us feedback as to what worked for you.

22 June 2016