

Brainstorming: forces and laws of motion



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What this unit is about

This unit will introduce you to a classroom technique called brainstorming.

Brainstorming involves collecting ideas from your students. It is a simple technique that allows students to think creatively and freely and without inhibitions. An initial 'prompt' is used as a stimulus and then students are encouraged to contribute ideas that are associated with that prompt.

It works because during the process there are no criticisms or judgements made of your students' suggestions. This has the effect of making students feel that they can offer all the ideas that they think of, however wild, wrong, silly or unconnected they seem. Rather, they can simply open their minds to whatever thoughts occur to them in a free-association process.

It is these so-called 'wild-card' ideas that are the seeds of creative thinking. They will often set off a train of thought that leads to an unusual, or new or imaginative answer. Better still, they may link otherwise unconnected concepts or subjects. Some of the suggestions that students will generate will not be useful, but that is OK.

In the first stage of the process, all ideas are acceptable and should be written down by one person. Brainstorming can involve a pair of students, a group of students or the whole class, and the prompt should be open-ended to encourage a wide range of ideas.

Once all the ideas have been collected, they can then be used in many different ways to support further learning. This unit will help you to learn how to run a brainstorming session and to use the ideas from the brainstorming session to inform your teaching.

The examples in this unit are drawn from the Class IX topic 'Force and laws of motion', but brainstorming is a technique that can be used across the entire science curriculum. It can also be used in association with other techniques such as mind mapping or project work.

What you can learn in this unit

- How to run a brainstorming activity with your students.
- How to choose a suitable prompt for a brainstorm.
- How to use the results of a brainstorming session to support further learning.

Why this approach is important

Brainstorming allows you to find out lots of things about your students. By listening carefully to their ideas, you will find out what they already know about a topic you are about to teach, what they remember about something you have just taught, how they might approach a problem, and what things are important to them. It also provides an opportunity for them to think creatively and to make connections between ideas and topics.

Fast-growing economies need people who can think creatively and solve problems. Students who can think creatively are considered to be desirable employees. Creativity is not just about remembering, but also applying knowledge. It is about suggesting, extending and offering alternatives. It is about making links between different topics and subjects.

For students to be creative thinkers they need to be encouraged to think differently to produce original ideas. It is really important that they need to feel safe that these ideas will be welcomed and openly received.

Brainstorming's main benefit is that it develops creative thinking skills in you and your students. Figure 1 illustrates the other benefits that brainstorming can bring into your classroom.

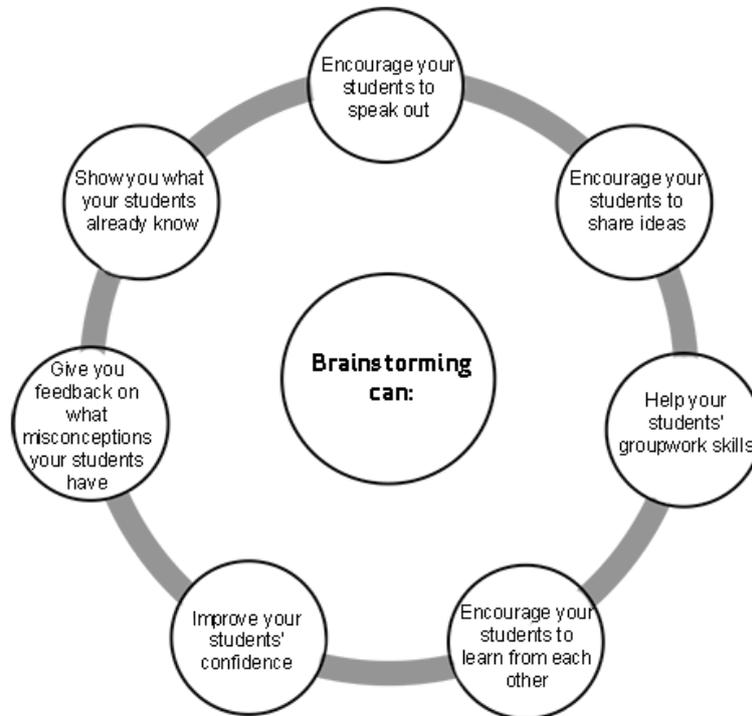


Figure 1 Classroom benefits of brainstorming.

Brainstorming is a very versatile technique because it can be used with any subject and can be done quickly. Because it is a group-based activity it can also be done relatively easily with large classes. It also gives your students the opportunity to talk about their ideas, and to learn from each other. Read Resource 1, 'Talk for learning', to find out more.



Video: Talk for learning

<http://tinyurl.com/video-talkforlearning>

1 How to brainstorm

First, you should reflect on any previous experiences you or your have had in taking part in a brainstorm. Note that in this unit, 'brainstorm' is used as both a noun (the brainstorming session) and as a verb (participating in the process of brainstorming).



Pause for thought

- Have you tried brainstorming yourself?
- Is it something that you think your students will be familiar with?

It is likely that you will have worked with colleagues to share ideas. In a 'true' brainstorm, the thinking is open and broad. Some of the initial ideas will eventually be rejected, but in the first stage it is important

that everyone has the chance to contribute anything they think of. If they have never done it before, it might take your students a few attempts before they get used to this way of thinking and working.

Brainstorming is an informal process and only has a few simple rules. It does not require a lot of setting up or advance preparation. It can be done at any time during a lesson or sequence of lessons, and there is no optimum or fixed time limit for it. Brainstorming works best when done in a group.

The process is started off with a prompt, which can be in the form of a question, a word, a statement, a photograph or a picture. Students are then encouraged to think about anything they can that is related to the prompt. All their ideas are recorded without judgement. Only after the ideas-generation session has ended are the responses discussed and evaluated, and then either kept or discarded.

Brainstorming rules

1. **Criticism is not allowed:** Adverse judgement of ideas must be withheld until later.
2. **Being unconventional is welcomed:** The wilder the idea, the better. Inappropriate ideas can be rejected later.
3. **Quantity is good:** The greater the number of ideas, the better the process works.
4. **Combination and improvement are sought:** In addition to contributing ideas of their own, students should suggest how the ideas of others can be turned into better ideas, or how two or more ideas can be joined into yet another idea.

Activity 1: Brainstorm 'force and laws of motion' with your colleagues

This activity is for you to do on your own or with other teachers. You will need a piece of paper, a pen, and of course your imaginations – that's all!

The purpose of this activity is for you to learn how to brainstorm. As you brainstorm, you will also be able to think creatively about how the ideas that students will learn about forces and motion apply to their everyday lives, and use these ideas in your lessons.

Write 'Forces and motion in everyday life' in the centre of the piece of paper. Think about the daily lives of your students and write down as many examples as you all can think of where the things they will learn about in this topic are relevant to what they are doing. Examples are: opening a door, lifting a wheelbarrow or oiling a bicycle. All of these demonstrate scientific principles, such as levers and friction. Think about the sports they play, the tasks they do at home, and the transport they use. You could extend it to include things that they don't necessarily do, but that they might see on television or in films, such as parachute jumping, streamlined trains or space travel.

Hopefully your piece of paper will soon be covered in ideas. The process will have been helpful, because it will have encouraged you to think more creatively about teaching the topic of 'Force and laws of motion'. You will be able to use these examples when you are explaining some of the scientific principles. However, there is more to brainstorming than gathering ideas. You need to use the ideas to support learning.

Underline all the ideas that are associated with your students' daily routine. These could be the basis of a homework exercise. For example, you could ask your students to explain the science behind certain activities that they are likely to do. They should draw force diagrams and include force arrows.

Draw a circle around all the ideas associated with sport. Are there any of these that you could demonstrate in the classroom, or by going outside the classroom? Look at the syllabus and work out two or three simple demonstrations that you could get your students to take part in.



Pause for thought

- How did your brainstorming activity go? Did you find it an easy or difficult experience?
- How creative were you able to be about 'force and laws of motion' using brainstorming?
- How can you use the results of your brainstorming session to help you plan your lessons on 'force and laws of motion'?

2 What makes a good brainstorming prompt?

You should think about the purpose of the brainstorming session from two perspectives:

- What science will it help your students to learn?
- What skills will they learn in the process?

The prompt that you choose will depend on the science you want your students to learn, and how you organise the session will depend on the skills you want them to practise.

Using a simple word like 'force' as the prompt would enable you to find out at the start of a topic what your students already know. More specific prompts like 'How do forces help us in our daily lives?' or even 'What would the world be like with no friction?' are probably best suited to finding out about student misconceptions.

It is important to have a prompt that will stimulate plenty of ideas, so it needs to be an open question or a problem with no single correct answer.



Figure 2 A simple demonstration with a question can form a suitable prompt. For example: How could you stop the roller skate from moving?

Activity 2: Thinking of suitable prompts for brainstorming

This is a planning activity for you to do on your own or with other teachers. The purpose of this activity is to help you think about suitable prompts.

Remember that a prompt can be a question, a word, a statement, a photograph or a picture.

The prompt that you use for a brainstorming session will depend on what you want your students to learn. Some possible learning outcomes might be:

- finding out what your students already know about forces and motion
- thinking deeply about a particular issue in a topic
- making connections between different topics and subjects
- relating science to everyday life.

For each learning outcome, think of a suitable prompt that would make your students think broadly about forces and the laws of motion.

When you have finished, compare your ideas with the table in Resource 2.

Finally, think about the topic that you will be teaching next. Plan two brainstorming prompts that you could use for that topic.

3 Brainstorming responses

There are different ways of recording brainstorming responses. The way in which you ask your students to record information will depend on what you want to get out of the activity.

Case Study 1: Mrs Gupta runs a brainstorming session on 'Force and laws of motion'

Before I started teaching forces and motion, I looked at the elementary science curriculum. I read that my students had studied forces and friction, but had done nothing on motion. I also realised that it would be helpful to know what they remembered about this topic.

It was a large class (about 80 students) so I divided them into groups of eight. I did not have any large pieces of paper, so I taped two pieces of A4 together to make A3 sheets. Each group had one piece of paper. I asked them to write 'Forces' on one side and 'Friction' on the other. I told them to think back to their time at elementary school and gave them ten minutes to write down everything they remembered about each topic. After ten minutes I collected in the pieces of paper.

Then I wrote on the blackboard: 'When is friction helpful?' and 'When is friction a problem?' Each group was given some Post-it notes and asked to write down as many answers to one of the questions that they could think of. While they were doing the second brainstorm, I stuck the papers from the first activity on the wall. But I still managed to listen to what they were talking about. One student, Sangay, had some amazing ideas. He is usually very quiet, but seemed to enjoy this activity.

When they had finished, I gave them a few minutes to walk around and look at the posters on the wall, while I stuck the Post-it notes on the blackboard. At the end, I read out some of the ideas from the Post-it notes. They soon realised that friction was complicated – sometimes you need it and sometimes you have to try

and reduce it. This led to a discussion about some of the ways we can reduce friction.

Halfway through the second activity, the head teacher came into the classroom because someone had complained about the noise. She looked cross and I was very worried. But when I showed her the posters, she realised that my students had been working hard. I explained that I had found out from the brainstorm that they did not remember much about friction, and that I was going to have to re-plan my lesson on Newton's first law of motion for the next day.

Mrs Gupta's class used both small and big pieces of paper (the Post-it notes and A3 sheets) to record the brainstorming responses. You could also use the blackboard, or a flipchart – it depends on what you have available and on what you want to do next. It is helpful to be able to keep the results of the brainstorm – especially if you are using it to find out what your students already know about a particular topic. If you have recorded the brainstorm on the blackboard, you could photograph it on your mobile phone for future reference. Having a record allows both you and your students to see how their thinking develops during the topic.

4 Completing a brainstorm

Once the ideas have been generated, you need to think about how to use them. Simply generating the ideas might be enough and you can put the results of the brainstorm on the wall so your students can refer to them. However, as you saw in Activity 1, using the ideas can lead to further creativity. During that activity, you were asked to use your brainstorm to design a homework activity and a demonstration to enhance your teaching.

There are many other methods that you can use to finalise the brainstorming process. You can ask your students to:

- pick out the three (or five, or ten) most sensible (or important, or significant) ideas
- look for patterns or connections
- discuss accuracy (you may need to correct some ideas if they are scientifically incorrect)
- write a list (the easiest but possibly the least imaginative option)
- create a mind map or a concept map (refer to the relevant units)
- draw a poster
- record a voice clip (you might use a phone to do this)
- create a cartoon to represent their final agreed selection.

If you want your students to make a mind map, for example to summarise a topic, a brainstorm can provide a useful starting point. Gather ideas on the blackboard, then ask your students to work in pairs to organise the ideas into a mind map.

5 Running a brainstorming activity in your classroom

The next step is to consider the practicalities of doing brainstorming in your classroom. There are three key issues:

- What will you do to ensure that the activity supports learning?
- How will you use the ideas from the brainstorm?
- How will you organise the classroom? Will you work with the whole class or put your students in groups? How will you organise the groups?

Usually, for brainstorming the groups should be as varied as possible in terms of gender and attainment, but you can also think about sometimes grouping students by attainment and giving them prompts of differing complexity, just to vary the activities for your students.

Activity 3: Planning a brainstorming activity to introduce a difficult part of the 'force and laws of motion' topic

This activity will help you to prepare a brainstorming exercise with your class on a difficult part of the 'force and laws of motion' topic.

Choose one particular aspect of the forces and motion topic that your students find difficult. For example, it could be 'inertia and mass', 'conservation of momentum', or any of Newton's three laws of motion.

Write down the learning outcomes that you want from the brainstorm. There should be one learning outcome related to the science that you want them to learn, and one linked to the skills you are trying to promote. For example:

- to find out what your students know and understand about mass, based on the work they did at elementary school
- to give students the opportunity to listen to each other and work collaboratively in a team.

Think of a prompt that you can give to your students. You could use one of the ideas that you thought of in Activity 2. Make sure your prompt will interest them and start them thinking about what they already know. Decide how to record and structure your students' responses. Will you use large paper? Their books? The blackboard?

Plan how to group your students. You will need to think about how you will explain to your students what they are required to do and what the rules are. Put these rules for brainstorming on a poster so that you do not have to mention them every time.

Finally, think about what you will do next to move their learning forward. Then carry out your plan at the first opportunity.



Pause for thought

- Did all your students participate?
- Were there any students who did not participate?
- How could you ensure they all participate next time?

Brainstorming is an activity in which all students can participate. It gives you an opportunity to notice individuals; it can give students confidence and it is a technique that can be used flexibly. You may want to look at the key resource 'Involving all' (<http://tinyurl.com/kr-involvingall>).



Video: Involving all

<http://tinyurl.com/video-involvingall>

6 Different approaches to brainstorming

Read here a teacher's account of how he used the brainstorm technique with his class.

Case Study 2: Mr Prashad reflects on running his first brainstorming session

Mr Prashad was about to start teaching forces to his Class IX students. He decided to adapt some of the ideas he had read about in this unit to run a brainstorming session.

I organised my students into their usual groups. I gave each group a small ball, which was placed on the desk in the middle of the group. I also gave each group a large piece of paper and asked for a volunteer in each group to act as scribe. In the middle of the page they wrote the word 'Force'.

I asked three groups to think of as many ways as they could to start the ball rolling. I asked the other three groups to think of as many ways as they could to stop a rolling ball. They got into discussion very quickly, brainstorming lots of ideas and using the ball to demonstrate to each other and think about new ideas between them. I was pleased to see that even the quieter students offered suggestions and often there was laughter at some of the more bizarre ideas.

After ten minutes I paused the discussions and asked them, 'What is your favourite idea, how might you demonstrate it to the rest of the class and who will your demonstrator be?' Each group then came and demonstrated, so we had three very different examples of how a ball might start rolling and what could stop it.

Back in their groups I then told them, 'Look at your brainstorm list, think about the demonstrations and decide what all your suggestions have in common.' I asked each group what conclusions they had come to and then linked their responses (that the ball only started moving or stopped moving because of a force) to the forces diagram that I had on a poster.

This brainstorming activity was now over, but I was confident that they really understood Newton's first law of motion. I asked students to bring their pieces of paper and their balls to the front and we put the brainstorm lists on the wall in case we needed to look at them again. I was really impressed with how creative their responses were.

Mr Prashad took an idea from this unit and adapted it. Many successful teachers have this ability to 'borrow' or adapt teaching techniques they see being used in other lessons or contexts for their own class. The discussion following a brainstorm is very helpful for learning because the students work with each other to construct the answers rather than being told the answer by the teacher.

7 Summary

This unit has explored ways of giving you and your students a technique that supports creative thinking skills, and helps you to find out about your students' thinking and prior knowledge. This technique is known as brainstorming.

Brainstorming can be used to support science learning in any topic. It is particularly useful as a way of revising previous topics. It is also a good way of involving all your students in the lesson and of promoting 'talk for learning'.

The key elements of the technique are:

- thinking of a suitable prompt
- planning how to record the responses
- planning what to do with the responses to support further science learning.

Resources

Resource 1: Talk for learning

Why talk for learning is important

Talk is a part of human development that helps us to think, learn and make sense of the world. People use language as a tool for developing reasoning, knowledge and understanding. Therefore, encouraging students to talk as part of their learning experiences will mean that their educational progress is enhanced.

Talking about the ideas being learnt means that:

- those ideas are explored
- reasoning is developed and organised
- as such, students learn more.

In a classroom there are different ways to use student talk, ranging from rote repetition to higher-order discussions.

Traditionally, teacher talk was dominant and was more valued than students' talk or knowledge. However, using talk for learning involves planning lessons so that students can talk more and learn more in a way that makes connections with their prior experience. It is much more than a question and answer session between the teacher and their students, in that the students' own language, ideas, reasoning and interests are given more time. Most of us want to talk to someone about a difficult issue or in order to find out something, and teachers can build on this instinct with well-planned activities.

Planning talk for learning activities in the classroom

Planning talking activities is not just for literacy and vocabulary lessons; it is also part of planning mathematics and science work and other topics. It can be planned into whole class, pair or groupwork, outdoor activities, role play-based activities, writing, reading, practical investigations, and creative work.

Even young students with limited literacy and numeracy skills can demonstrate higher-order thinking skills if the task is designed to build on their prior experience and is enjoyable. For example, students can make predictions about a story, an animal or a shape from photos, drawings or real objects. Students can list suggestions and possible solutions about problems to a puppet or character in a role play.

Plan the lesson around what you want the students to learn and think about, as well as what type of talk you want students to develop. Some types of talk are exploratory, for example: 'What could happen next?', 'Have we seen this before?', 'What could this be?' or 'Why do you think that is?' Other types of talk are more analytical, for example weighing up ideas, evidence or suggestions.

Try to make it interesting, enjoyable and possible for all students to participate in dialogue. Students need to be comfortable and feel safe in expressing views and exploring ideas without fear of ridicule or being made to feel they are getting it wrong.

Building on students' talk

Talk for learning gives teachers opportunities to:

- listen to what students say
- appreciate and build on students' ideas
- encourage the students to take it further.

Not all responses have to be written or formally assessed, because developing ideas through talk is a valuable part of learning. You should use their experiences and ideas as much as possible to make their learning feel relevant. The best student talk is exploratory, which means that the students explore and challenge one another's ideas so that they can become confident about their responses. Groups talking together should be encouraged not to just accept an answer, whoever gives it. You can model challenging thinking in a whole class setting through your use of probing questions like 'Why?', 'How did you decide that?' or 'Can you see any problems with that solution?' You can walk around the classroom listening to groups of students and extending their thinking by asking such questions.

Your students will be encouraged if their talk, ideas and experiences are valued and appreciated. Praise your students for their behaviour when talking, listening carefully, questioning one another, and learning not to interrupt. Be aware of members of the class who are marginalised and think about how you can ensure that they are included. It may take some time to establish ways of working that allow all students to participate fully.

Encourage students to ask questions themselves

Develop a climate in your classroom where good challenging questions are asked and where students' ideas are respected and praised. Students will not ask questions if they are afraid of how they will be received or if they think their ideas are not valued. Inviting students to ask the questions encourages them to show curiosity, asks them to think in a different way about their learning and helps you to understand their point of view.

You could plan some regular group or pair work, or perhaps a 'student question time' so that students can raise queries or ask for clarification. You could:

- entitle a section of your lesson 'Hands up if you have a question'
- put a student in the hot-seat and encourage the other students to question that student as if they were a character, e.g. Pythagoras or Mirabai
- play a 'Tell Me More' game in pairs or small groups
- give students a question grid with who/what/where/when/why questions to practise basic enquiry
- give the students some data (such as the data available from the World Data Bank, e.g. the percentage of children in full-time education or exclusive breastfeeding rates for different countries), and ask them to think of questions you could ask about this data
- design a question wall listing the students' questions of the week.

You may be pleasantly surprised at the level of interest and thinking that you see when students are free to ask and answer questions that come from them. As students learn how to communicate more clearly and accurately, they not only increase their oral and written vocabulary, but they also develop new knowledge and skills.

Resource 2: Some prompts for brainstorming forces and motion

Table R2.1 Brainstorming on 'forces and motion'.

Learning outcome	Prompt	Comment
Finding out what your students already know about forces and motion	'Forces and motion'	Encourage your students to think about what they learnt at elementary school.
Thinking deeply about a particular issue	'What would the world be like if there was no friction?' 'Imagine a rolling ball. Think of all the ways to stop it.'	This will really test their imaginations and make them think about the consequences of friction. This will help students to understand that forces are required to make things move or to stop things from moving.
Making connections between different topics and subjects	'Energy'	Students will have come across the word 'energy' in many different contexts. This will help them to draw together what they have learnt in Physics (energy transfer), Chemistry (how to generate energy) and Biology (how living things get their energy).
Relating science to everyday life	'What levers have you used today?' 'How do forces help us in our daily lives?' A photograph of a children's playground, or a building site with crowbars and pulleys	These prompts will help students to understand that science is all around them and not just in a science classroom. Remember that images and pictures can also be used as prompts.

Additional resources

- An OpenLearn unit, *Describing motion along a line*: <http://www.open.edu/openlearn/openlearn/science-maths-technology/science/physics-and-astronomy/describing-motion-along-line/content-section-0> (accessed 20 May 2014)
- Various forces and motion videos: <http://blossoms.mit.edu/> (accessed 20 May 2014)
- Newton's first and third laws are available from the NSTA Learning Center's website (the content is free but you will need to register in order to be able to download the resources): <http://www.learningcenter.nsta.org/> (accessed 20 May 2014)

- Forces and motion for developing teachers' subject knowledge:
<http://www.ase.org.uk/resources/scitutors/subject-knowledge/k42-forces-and-motion/> (accessed 20 May 2014)

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