I'm a Scientist Get me out of here

Self-driving Cars

The Royal Institution Science Lives Here

Lloyd's Register Foundation

IOP Institute of Physics

This kit has been produced by the award-winning *I'm a Scientist* team and funded by the Royal Institution, the Institute of Physics, and Lloyd's Register Foundation.

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Rachel Fong - Rural mum

I've got two children under 3 and I live in a rural village. I often come into town to go to the shops, go to soft play, visit friends or family. It's a nightmare getting two kids into their car seats and all their stuff, plus the shopping, in the boot. I would just stop coming into town altogether if I couldn't drive in. I'm happy with things the way they are, we don't always need 'progress'.

Fact: Self-driving cars are far more expensive than ordinary cars, and likely to remain so for a long time.

Issue: This seems like it's going to make a lot of people's lives LESS convenient, just for the sake of shiny new tech.

Question: Who is going to be able to afford to drive into the city centre? Do we want only rich people to have convenience?

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Dara Attar – Tech entrepreneur

Self-driving cars are the future. And to be honest, they are just cool! We should be leading in this technology. There are different levels of autonomous car technology - from level 1, which is things like cruise control, to 5, which is a car that doesn't need a driver at all and can drive itself in any situation. Level 4 is a car that drives itself - a true driverless car - but that only operates in a particular, controlled area - like our town centre. We need a lot of practice at level 4 in order to get to level 5 and truly unlock this technology.

Fact: A government report says that self-driving cars could be worth an extra £52 billion to the UK economy by 2035.

Issue: Self-driving cars are coming, whether we like it or not.

Question: Shouldn't UK business get in there, get involved, and reap the benefits?

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Dave Lyons - Warehouse Operative

I think self-driving cars are a great idea, but I think this is the wrong way to go about it. Human error causes about 75% of car accidents, which is why I'm a fan of self-driving cars. Computers don't drink and drive, get distracted or drive when they are tired. But we should start with lorries carrying freight. They do a lot of miles, often on rural roads, and they follow set routes - perfect for level 4 technology.

Fact: Most people who are killed in car accidents aren't in city centres (where traffic moves slowly), they are killed on rural roads.

Issue: Computers are good at 'bottom up' processing (e.g. seeing edges of objects), but they aren't good at 'top down' processing - e.g. knowing what a cat is and what it might do. City centres don't play to their strengths.

Question: Should we give up our city centres without getting the real benefits of driverless car technology?

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Fiona Campbell - City planner

The UK population is increasing, and people make more car journeys all the time. Our towns and cities need to accommodate that. Self-driving cars could mean a system of pooled cars (like robot taxis) and so far fewer cars would be needed to drive everyone around. These cars could be connected and talking to each other, and reduce congestion. It's easier for level 4 self-driving cars to operate in the centre if they don't have to deal with normal cars too.

Fact: Today's cars are only being used 3.5% of the time. They are parked 96.5% of the time.

Issue: Connected autonomous cars can make thousands of calculations every minute and be safer and more efficient than humans.

Question: Does it make sense for everyone to have their own car, but only use it so little of the time?

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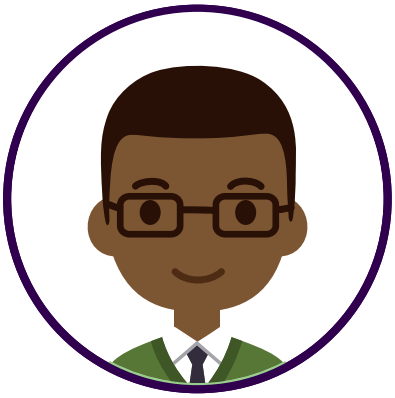
Michael Owuo - Epidemiologist and cyclist



I'm a scientist who studies what makes people ill and how to make the health of the whole population better. 'Active travel' - walking and cycling - makes so much sense, especially for short journeys. It makes us fitter, healthier and happier, and it doesn't cause pollution and congestion. It's also good for communities, we say hello to people, we pop into local shops. Fewer car journeys overall are better for us, better for our communities, and better for the planet!

Fact: In the 1970s the Netherlands invested in cycling infrastructure and promoting cycling. Now over ¼ of all trips are made by bicycle - compared to 2% in the UK.

Issue: We should prioritise making our towns more walkable and bikeable - not still centre them around the car!

Question: Can you hand on heart say that self-driving cars will REDUCE the number of journeys people make by car?

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Lisa Dixon - Taxi driver

I've been driving a taxi for ten years, and I really love my job. I'm 'Lisa's Lady Cabs'. Lots of women feel happier with a female taxi driver, especially travelling on their own, late at night. I'm company for people. One old lady books me every week and takes flowers to her husband's grave. She tells me about her life and when she was young. A computer algorithm wouldn't be the same for her.

Fact: One study suggests that 1.2 million driving jobs could be lost in the UK - for example, taxi drivers, bus drivers, delivery drivers.

Issue: If we get rid of human beings, we lose the human touch. Life shouldn't only be about what's most efficient.

Question: No computer system is unhackable. My customers feel safe with me, will they be as safe with a computer programme controlling where they go?

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Kazik Majewska - Commuter

I commute for two hours each day. I have a specialist job and I can't get a job anywhere closer. We live in the village my wife grew up in, and her parents help with childcare for our young twins. We can't move to be nearer work. There's no bus route I could use, but I hate spending so much time driving each day.

Fact: In 2016 3.7 million people in the UK commuted for two hours or more each working day. That's 32% more than in 2010.

Issue: A self-driving car can use cameras or lasers to detect its surroundings, lots of computing power, and advanced AI to drive the car more safely than I can, while I do something more interesting!

Question: I don't wash clothes by hand, I use a washing machine. Why would we still want to do boring jobs that machines can do for us?

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Bethany Fisher - Sight impaired person

I am sight impaired. It's not severe and I can see things, but it is very blurry - like a fully sighted person looking at the world through a piece of fabric. Of course I can't safely drive a car. Sometimes (especially at night) it's even very hard for me to get a bus or walk somewhere. And taxis are expensive. Driverless cars would transform my life.

Fact: There are 350,000 people registered blind or partially sighted in the UK, and 2 million living with sight loss that affects their lives (e.g. they are not able to drive).

Issue: Driverless cars mean that many people would be able to make journeys independently, for the first time. This includes people with impaired sight and some other disabilities, teenagers and old people.

Question: Not everyone can drive, walk or cycle. Don't I deserve the same freedoms that other people take for granted?

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Kit N°12

Teacher Notes

***Question:* Should our town centre be for self-driving cars only?**

Lesson plan

The different 'rounds' of the debate help students think through the issues and reconsider their opinions. The structure also shows them how to build a discussion and back up their opinions with facts.

Starter: 5 minutes.
How do they think the invention of cars affected the world? Prompt, if necessary, them to think about: the environment, how cities and towns are laid out, how people live, where they live, where they work, communities, families.

Do they think people foresaw all those effects when cars were first invented?

Engineers are developing driverless car technology right now. Today we're going to think a bit about what that might mean in the future.

Designed for KS4. These debate kits have been used with ages 11-18.

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Main Activity: 35 minutes.
1) **Split students** into as many groups as characters you want to cover.
2) **Give** them their character cards – one per group, and give them a few minutes to read them over.
3) Get one student in each group to **read out** their **first section** to the rest of the class.

What are the class's initial thoughts? Is there one position they identify with or reject?
4) Take it in turn to **read out** their **fact**. Does it change the way they think?
5) **Read** the **issue**. Any different feelings?
6) Each team **asks** their **question to** the **character of their choice.**

Support: To help students you can put the following prompt sentences up on the board:
"I think our town centre should/shouldn't be for self-driving cars only because..."
"I think …… is the most important point to think about."

Plenary: 10 minutes
Vote for which position they agree with most (if there is one). Why? Which arguments were the most persuasive?

Note – Pupils can stay in roles all the way through debate, or only for the first round if you prefer. If it's all the way through, give them a chance to express their own opinion at the end and in the plenary.

For groups who are not confident at class discussion, it might help to have them start by discussing the question and/or their character's position in pairs, and then compare notes in fours. They've then had chance to rehearse some of what they want to say before having to do it in front of the whole class.

Background notes

Self-driving cars
Self-driving cars (also called autonomous vehicles) are vehicles which can sense the environment around them and travel safely without human input (or with less human input than a 'normal' car). There are five levels of 'driverless' technology. (Sometimes referred to as six, to include standard car technology).

Level 0	Standard car technology, the human does all the driving
Level 1 'hands on'	A single element of the driving process has been taken over by the car - e.g. cruise control, or lane-keep assist.
Level 2 'hands off' - but not literally!	Computers can take over multiple functions from the driver, bringing together information from various sensors to control the speed and direction of the car much of the time. Humans still need to be 'hands on' at all times - monitoring the driving and ready to intervene in an emergency.
Level 2+	Not exactly a 'level', but this is where today's most advanced vehicles are up to. They are beyond level 2 - they are integrating more sensor data, including monitoring the driver. But they are not yet at level 3.
Level 3 'eyes off'	The driver can safely turn their attention to other things for much of the time. The vehicle can handle braking in an emergency, but the driver must be available to intervene within a limited time, if the vehicle alerts them.
Level 4 'minds off'	The vehicle is totally responsible for driving and the human driver can leave the driver's seat, or sleep. But, the vehicle can only operate in geofenced areas, where very detailed mapping is available, lane markings and road edges are clear (e.g. city centres, or an airport car park), or under special circumstances (e.g. a traffic jam). Outside of these areas or circumstances, the car will alert the driver, and safely park themselves if they don't respond.
Level 5 'steering wheel optional'	The vehicle doesn't need a human driver, ever, and can correctly and safely control itself in every circumstance that a human driver could. For example, parking on a field at a school fete, and following the hand signals of a volunteer. Will require very advanced AI. Different experts predict this will be available within 10-30 years, some say it will take 100 years. It is notoriously difficult to predict technological development accurately.

Key issues
Level 2/2+ presents some difficulties that aren't present when we get to level 3 or 4. Humans are not good at switching attention and they are not good at paying attention for a long time when they mostly aren't needed. If you aren't engaged, you get distracted after about 20 minutes. If the car suddenly alerts you, 'help, we are about to crash!' it takes time for you to return your attention to the road and work out what is going on.

Working out information about the environment around you depends on, broadly, two kinds of processes:-
1. Bottom-up processes (for example, in visual processing, detecting edges)
2. Top-down processes (for example, you know what a cat is and how it might behave)

Currently, computers are very good at 1, but not very good at 2. They don't have 'common sense' and can't make inferences, for example, to predict what a pedestrian might do. We will need a lot of advances in AI technology to get driverless cars to level 5.

Human drivers ARE good at top-down processing, and can cope with many situations that driverless cars won't be able to cope with for a long time (if ever). Level 3 and 4 cars may need us to change the road environment - making edges clearer, banning pedestrians, bicycles, buggies, ice cream vans…

Most driverless cars are being developed and tested in places like Palo Alto, California, where roads are wide and straight, and laid out on a grid pattern, and there is little mixed road use (i.e. cyclists and pedestrians). And where the weather is usually dry and sunny. Having the same technology work in the centre of York on a rainy Saturday is more of a challenge.

Many of these technologies are sensing objects around the car in different, complementary, ways: for example, cameras don't work well in low light, radar works best for metal objects, ultrasonic sensors only work over small distances but can 'see through' some objects.

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All the facts in this kit have been researched. References can be found online at: (cars.imascientist.org.uk)

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The kit has been produced by the I'm a Scientist team and funded by The Royal Institution, Lloyds Register Foundation and Institute of Physics.

There are big questions about exactly how the driverless car future is going to work. At the moment development is mainly being driven by the luxury car market - the vehicles are expensive. As early adopters with large disposable incomes start using driverless cars more - what happens to other road-users?

Some people suggest that we will next have robot taxis - the driver is 70% of the cost of a taxi, so robot taxis could be cheaper. If people who can afford it switch to robot taxis, that could mean only the poorest will still use buses. This could lead to less funding for public transport, and 'transport deserts', in poorer areas.

Cyber security around driverless cars raises a lot of issues - we could have written a whole kit about that, but then we'd have missed out many other issues. But your students may want to think about what could happen if your driverless car computer was hacked? And whether the security services should be able to override the computer on your driverless car?

Important technologies that make self-driving cars possible

- Cameras to sense what is around the car.
- GPS to determine the car's location.
- Altimeters, gyroscopes, and tachymeters to keep track of the precise position of the car.
- Radar, a system that uses radio waves to work out the range, angle and velocity of objects.
- Lidar, a sensing system which follows the principles of radar, but uses light from a laser. Detects what is around the car.
- Ultrasonic sensors detects objects near the vehicle, and the car's movements.
- Advanced AI/computer systems to integrate all this data, maps and knowledge about road signs, driver behaviour, etc.

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Kit No. 12

Science Debate Kit: Self-driving cars

"Keep these kits coming please!"

For in-depth online resources on this debate go to: cars.imascientist.org.uk

Debate Kit: Self-driving cars

Should our town centre be for self-driving cars only?

A structured practice debate on a controversial topic
The different 'rounds' of the debate help students think through the issues and reconsider their opinions.
The structure also shows them how to build a discussion and back up their opinions with facts.

You can use all eight characters, or fewer, as you wish.

The minimum is the four essential characters (**in bold**), this gives two for and two against.

Characters

Yes	No
• **Dara Attar – Tech entrepreneur**	• **Michael Owuo - Epidemiologist and cyclist**
• **Fiona Campbell - City planner**	• **Lisa Dixon - Taxi driver**
• Bethany Fisher - Sight impaired person	• Rachel Fong - Rural mum
• Kazik Majewska - Commuter	• Dave Lyons - Warehouse operative

Facilitation tips

- Ensure pupils know there is no right or wrong answer.
- Be observant of ones who want to speak and are not getting a chance.
- Encourage students to give a reason for their opinions.

Designed for KS4 but can be used with ages 11-18.

For groups who may need extra support you can put the following prompt sentences upon the board:
"I think we should/shouldn't make the town centre for self-driving cars only because..."
"I think …… is the most important point to think about."

Learning notes

Learning objectives:

- To practise discussing and debating issues and expressing an opinion

Other learning outcomes:

- Consider social, ethical and factual issues in an integrated way
- Think about different points of view
- Learn to back up their opinions with facts

Curriculum points covered:

Thinking scientifically

- Evaluating the implications of technological applications of science
- Developing an argument
- Reflecting on modern developments in science

Substantive

- Consider practical aspects of motions and forces, particularly driver and vehicle interactions and road safety.

"Particularly like the format plus the accuracy of the scientific information"