David Didau

Foreword by Paul A. Kirschner

Making Kids Cleverer

A manifesto for closing the advantage gap

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How do we make kids cleverer? How do we close the advantage gap? These are not easy questions to answer as the science of education and learning is far from exact. Our problem is made even more complicated by the fact that how a person learns is influenced by so many things – both internal and external – which are hard to grasp and even harder to control. This being said, there is one factor that can optimise learning, make kids cleverer and, potentially, play an enormous role in closing the advantage gap. That factor is the teacher.

As an educator and researcher in the field of educational psychology I've spent my whole academic career – which now spans four decades – studying how people learn and how the process can be facilitated through carefully designed interventions. What I've learnt in all those years, from all the studies I've conducted and from all of my attempts to help learners learn better (and maybe even to become cleverer), is that everything hinges on teachers.

For me, a teacher is an educational designer: a professional who designs, develops, implements and (hopefully) evaluates learning situations that are effective, efficient and enjoyable for the learner. That a learning situation is *effective* means that in the time allotted within a curriculum, either more is learned than was planned for or what is learned is done to a deeper level than expected or required. For a learning situation to be *efficient* the curriculum is mastered either in less time or is learned with less effort. Finally, *enjoyable* doesn't necessarily mean that lessons are fun (real learning is often difficult), but rather that the learner experiences success and, with that success, has a feeling of accomplishment and what is known as self-efficacy (i.e. I can do it!).

Ideally, a teacher should not be just a run-of-the-mill educational designer; they should strive to be the very best they can be: a top-quality teacher. In order to explain what I mean I will resort to an analogy with what it takes to become a top chef, both because I love to eat and because I myself – before I entered academia – worked as a chef in a restaurant. Top chefs perform their magic in restaurants that have attained the Nobel Prize of the gastronomic world, namely three Michelin stars. Such chefs are capable of planning and preparing tasty, healthy and beautiful dishes for anyone, be they children, finicky eaters, diners with allergies, or gourmets. And they can do this because they have deep conceptual knowledge and finely honed skills with respect to the tools (knives, ovens, pots, pans, stoves, mixers, blenders …), techniques (steam baking, hot-air baking, wood-fire baking, sautéing, deep frying, blanching, freezing, cryogenic cooking …), and ingredients (vegetables, meats, grains, spices, herbs …) of the trade. A top chef knows when, how and why to use each of the tools, techniques and ingredients and also has the skills to properly implement them to get the best results in any culinary situation.

Similarly, top teachers are capable of designing and preparing effective, efficient and enjoyable learning experiences for all students, be they average or advantaged, possessing special needs or blessed with particular talents. And they can do this because they have deep conceptual knowledge and finely honed skills with respect to *their* tools (whiteboard, textbook, e-reader, tablet, computer, laboratory …), instructional techniques that optimise different types of learning (lectures, discussions, debate, collaboration, formative and summative assessment, feedback techniques …), and ingredients of the teaching trade (different types of questions, prompts, tasks, examples, illustrations and animations, homework, simulations …). A top teacher knows when, how and why to use each of their tools, techniques and ingredients and also has the skills to properly implement them in different situations and with different students.

This being the case, I must confess that reading this book has made me really jealous! David Didau has essentially written what I would have loved to write myself. This is a book that can and will provide teachers – and anyone else interested in the project of education – with most if not all of the background knowledge they need to understand how kids learn and how to make them cleverer. As such, it can and will play an important role in closing the advantage gap. In my opinion, the book you have in your hands will help teachers to graduate from knocking out reheated meals in a second-rate diner to competent chefs turning out delicious, nutritious meals. Reading this book could help teachers become the equivalent of top quality chefs in Michelin starred restaurants.

Bon appétit!

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Chapter 5

Can we get cleverer?

Oh how fine it is to know a thing or two.

Molière, *The Middle Class Gentleman*

- Does going to school make us cleverer?
- Are we cleverer today than people were in the past?
- Is growth mindset or brain training a good bet for making children cleverer?

The question of whether or not we can get cleverer is a crucial one for this book, but there is also some evidence that people are becoming more intelligent as a matter of course. In *Are We Getting Smarter?* James Flynn answers his own question thus:

> If you mean 'Do our brains have more potential at conception than those of our ancestors?' then we are not. If you mean 'Are we developing mental abilities that allow us to better deal with the complexity of the modern world, including problems of economic development?' then we are.[1]

If you believe intelligence has a biological basis and that environmental effects are trivial, then you may be sceptical. But as we saw in the last chapter, environment matters. And it matters most for those from the most socially disadvantaged backgrounds. If we were only worrying about the middle classes, then maybe there would be little scope for further improvements, but we're not. The arguments laid out here are rooted in a belief in social justice. The most vulnerable children not only have the most to gain, but they are also the ones *most likely* to gain from our efforts to make them all cleverer.

School makes you smarter

One thing we can be fairly sure will raise children's intelligence is sending them to school. For as long as education has been compulsory, average IQs have been rising. We've seen in previous chapters that education and intelligence have a two-way interaction: the more intelligent you are, the longer you stay in school and the longer you stay in school, the more intelligent you become. To understand how we know this, we have to head back to Norway in the 1960s. The government of the day decided to mandate an additional two years of schooling for all children, but, as luck would have it, they made the decision to roll out the new policy over a number of years with some regions of the country lagging behind others. As a further piece of luck, young Norwegian men were required to serve a period of military service and – more luck – all conscripts had to sit an IQ test. This means that researchers can see the effects of the additional two years of schooling by comparing the average IQs of men from those parts of the country in which the new policy had been implemented with men from those parts in which it hadn't. Each extra year of schooling accounted for 3.7 IQ points.[2] Something similar happened over the border in Sweden where men entering military service at age 18 were also given routine IQ tests. Those with less schooling had lower IQ scores than those with matched IQ scores at the age of 13 and similar socio-economic status but who stayed in school for longer.[3] These sorts of effects have been demonstrated again and again.[4]

There are two main arguments against the effects of schooling on intelligence. One is that gains to intelligence are temporary and tend to disappear over time. This is exactly what happens to Charlie Gordon in *Flowers for Algernon*: although his IQ is raised to genius levels, it rapidly retreats back to where it was and the story ends as it began. Does life imitate art? As noted in the previous chapter, attempts to raise IQ through preschool interventions seem to quickly fade. But why would we expect a transitory change in our environment to have a permanent effect on our intellect? This is just wishful thinking. However, we can perhaps change children's habits of mind and instil in them a desire to keep cognitively fit as well as expanding what they know.

The second objection is that gains to intelligence are hollow. It's well known that anyone can improve at anything through practice. This applies to taking IQ tests as much as anything else. If you practise taking IQ tests, your score will go up, but will you be any more intelligent? Measured intelligence may not be the same as genuine intelligence.[5]

Perhaps schools teach the kind of knowledge IQ tests are looking for; Stephen Ceci has argued that "it makes intuitive sense that much of the knowledge that aptitude tests, including IQ tests, tap is accumulated through directed encounters with the education system".[6] This does indeed make intuitive sense. But why would anyone think that would be a bad thing? Ceci goes on to suggest that the effects of education on IQ are due to the kinds of knowledge schools teach. If a test asks what an apple and an orange have in common, full marks are awarded for classifying them both as fruit, but only half marks for pointing out their shape, taste or that they contain seeds. As we'll see later on in this chapter, the cultural shift towards abstract and hypothetical thinking not only leads to higher IQ scores, but also to real-world advantages. If this is the case, then calling such gains hollow is to miss the point entirely. Indeed, a recent meta-analysis has shown that increases in IQ brought about by changes to educational policy are very durable, lasting at least until people reach 70 years of age.[7]

So, could there be an argument for staying in school indefinitely? If we extrapolate from the Norwegian study, we could assume that staying in education for 11 years will raise IQ scores by over 40 points! Too good to be true? Perhaps. Given that the average IQ is set at 100, this would be a phenomenal difference. Unfortunately, this isn't something that has ever been directly tested because it would require a large scale randomised controlled trial in which some children are prevented from attending school. While many of the children I've taught over the years might have been willing to take part in such an experiment, I think most parents would baulk at the idea.

Happily, developmental psychologists Sorel Cahan and Nora Cohen came up with a nifty experimental design that circumvented this problem.[8] They used the fact that in a given school year children's ages can vary by up to a year. My youngest daughter was born in August, right before the cut-off date for the next academic year starting in September. As a result, she's very close in age to children who are a whole academic year behind her. In this way, Cahan and Cohen were able to measure the effects of a year's schooling on the IQ scores of children with roughly the same ages. They found the effects of education were twice as great as the effects of aging. This has since been confirmed by a number of subsequent studies.[9]

In a report challenging the hereditarian view that intelligence is mainly a product of our genes, Ulric Neisser and his colleagues point out that "schooling itself changes mental abilities, including those abilities measured on psychometric tests". They go on to say: "There is no doubt that schools promote and permit the development of significant intellectual skills, which develop to different extents in different children. It is because tests of intelligence draw on many of those same skills that they predict school achievement as well as they do."[10]

Although we know that education has lasting effects on specific aspects of cognitive ability, no one knows for sure what it is about education that causes the increases. This is important because if we did know which bits resulted in the greatest increases, we could make sure we did more of what was most effective. Douglas Detterman is emphatic that schools account for very little of the variance between students' outcomes, estimating that 90% of the differences will be due to variations in children's cognitive abilities, with just 10% accounted for by schools.[11] While this may be true, few children will acquire biologically secondary knowledge without going to school, and while 10% could be true on average, schooling will probably account for far more of the variance for less advantaged children. Indeed, there is some evidence that the children who benefit most from going to school are those who are most disadvantaged.[12] Keeping children in school for as long as possible is likely to help close the advantage gap regardless of us understanding exactly why, but how much better it would be if we knew.

Various commentators have speculated that the effect of education on IQ might be caused by changes in children's thinking styles, increases in self-control brought about through having to comply with standards of behaviour imposed by schools or the effects of both learning to read and reading to learn.[13] All are interesting potential candidates, but the question of what precisely education affects has now been fairly comprehensively addressed by Stuart Ritchie, Timothy Bates and Ian Deary.[14] They considered whether education directly affects general cognitive ability (*g*) or has a more specific effect on particular cognitive skills. They took a sample of over 1,000 people and tracked their cognitive development over a 60-year period from the age of 11 to 70. The 70-year-old subjects were given a battery of 10 different cognitive tests, and from these Ritchie and colleagues were able to conclude that the effects of education only persist in specific IQ sub-tests, but do not bestow a long lasting increase for *g*. So, what was education affecting?

The sub-tests that showed no persistent improvement were in fluid areas of intelligence like processing speed, working memory and reasoning, whereas tests for crystallised aspects – vocabulary, verbal reasoning and arithmetic – showed persistent gains. It seems that those aspects of intelligence that flatten off are biologically primary modules, whereas those that continue to improve are the product of secondary knowledge. As we saw in Chapter 2, that which is biologically primary is learnable but not teachable, while that which is biologically secondary is the result of learning culturally accumulated knowledge. To explore this idea further, we now need to turn our attention to the idea that intelligence is both fluid and crystallised.

Fluid and crystallised intelligence

In the 1940s, the psychologist Raymond Cattell first proposed that intelligence should be separated into fluid and crystallised intelligence, and he continued working on the idea for decades.[15] Fluid intelligence is our raw reasoning power. It's usually defined as the ability to handle data and use logic to solve novel problems without relying on prior knowledge. It includes the capacity to store new information in long-term memory and is correlated with working memory capacity as well as our ability to focus our attention and impulse control. Crystallised intelligence is the ability to access and utilise information stored in long-term memory. This includes our vocabulary, knowledge of arithmetic and understanding of how the world works, as measured by questions like, 'Why do streets have consecutively numbered houses?'* While both these aspects of intelligence are correlated with each other, their separate existence has important implications for making kids cleverer. As we'll see, increasing

* To make it easier to find individual houses. House numbering first occurred for the convenience of the Royal Mail.

crystallised intelligence is relatively straightforward, whereas fluid intelligence appears to be much less malleable.

Consider the example of a Swedish study showing an IQ gain associated with additional days of school. Like Ritchie and his colleagues, the researchers noted that extra schooling had a marked effect on synonym recognition and technical comprehension, while scores on logic and spatial reasoning tests showed no improvement.[16] It should be clear that recognising a synonym is a product of what we know, as is the ability to comprehend a passage of text. Logic and spatial reasoning sub-tests tap into the fluid aspects of intelligence and so we should not be surprised to see that they don't improve. The rule seems to be that education raises crystallised intelligence but not fluid intelligence.

While we might be getting smarter, we're not getting any faster. In 1981, researchers tested the vocabulary and processing speed of children aged between 6 and 13 and then returned to the same school 20 years later to assess a different group of children with the same tests. The later generation had better vocabularies but their ability to process information was no better.[17] Processing speed is clearly linked to working memory and, as we will see, working memory is closely correlated with fluid intelligence. The crystallised nature of vocabulary seems to confirm that we can raise one but not the other.

What IQ test questions are like

As we've been considering IQ sub-tests, it's past time to have a look in more detail at the sorts of questions used to measure each of these components. Matrix reasoning tests are widely considered to be the best test of fluid intelligence because you are meant to be able to work out the answer without prior knowledge.* Figure 5.1 is a fairly straightforward example.

Select a suitable figure from the four alternatives that would complete the figure matrix:

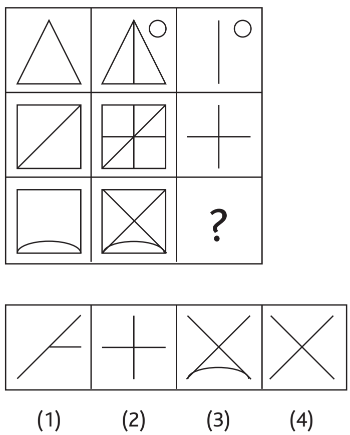

Figure 5.1. Example of a matrix reasoning question

They can get a lot harder.

An example of something that would test crystallised intelligence is a vocabulary test. Clearly, you can only answer the following question with

* It is probably naive to claim *no* previous knowledge. While a test-taker may not know about particular patterns, most people have had years of experience of finding similarities and making analogies – something the brain is hard-wired to do. For example, we are well able to sit on previously unknown chairs, open doors never encountered before, press buttons in lifts or keys on a phone all based on unconscious analogy-making. Maybe a better question would be to identify the extent of our unconscious natural ability, and where it merges into similarity, and find out what is more challenging and requires conscious effort. See Hofstadter and Sander, *Surfaces and Essences*.

any confidence if you have previously encountered the answer in some other context:

What is the best synonym for dismay?

1. Display
2. Jealousy
3. Provocation
4. Disappointment

A test of verbal reasoning may assess both fluid and crystallised intelligence. A question will require you to engage in some reasoning for which you won't be expected to have any specialised prior knowledge, but the better your vocabulary and general knowledge, the easier you're likely to find it.*

As children mature they get better at reasoning, as well as becoming more knowledgeable as they learn more about the world. But whereas crystallised intelligence continues to rise into our sixties, we start to haemorrhage fluid intelligence from our late twenties.[18]

These components of intelligence interact differently with memory. It turns out that while they're not the same thing, fluid intelligence correlates surprisingly well with working memory capacity. One of the most important things to understand about working memory is that no matter how clever you are – and contrary to the myth of multitasking – your capacity to pay attention to different ideas and facts at the same time is strictly limited. Although everyone's working memory is fragile, there's no doubt that some people have greater capacities than others. This confers a real advantage, and if we're interested in making children cleverer, it seems sensible to investigate how we can improve their working memories. Sadly, as we'll go on to explore, despite the claims of various brain training gurus, it doesn't actually appear to be possible to increase working memory capacity or fluid intelligence – what you've got is what you get.

However, although there is a link between fluid intelligence and learning – making changes in long-term memory – it's obviously true that everyone who falls within the normal range of human intelligence is capable

* For an example of this see www.verbalreasoningtext.org.

of storing memories. Due to their greater working memory capacity, someone with higher fluid intelligence will process more information in a given time and is more likely to retain more of it than someone with lower fluid intelligence. But given sufficient time everyone can remember stuff. The more knowledge we possess, the higher our crystallised intelligence will be. We'll explore the link between intelligence and memory further in Chapter 6.

We've seen that the general cognitive factor (*g*) suggests that being good at one aspect of an IQ test means you're likely to be good at all aspects. This in turn suggests that those people with higher fluid intelligence will also have higher crystallised intelligence. This is probably because a better ability to reason and process new information means you're likely to learn new information more quickly. But this is not fate. As we've seen, there's not much we can do to increase our fluid intelligence, but crystallised intelligence increases as our knowledge of the world expands – and what is this knowledge except distilled environmental influence?

The fact that at least some of what makes up intelligence is environmental is very important – it means we can do something about it. If we make a concerted and deliberate effort to help children to encounter and remember more information, they will be at a distinct advantage. If part of the measure of general intelligence is the ability to access items stored in long-term memory, then the good news is that there's no limit to the amount of stuff we can cram into the brain. Of course, what we know is subject to forgetting, but, as we'll see, we can improve access to our long-term stores of knowledge quite considerably.

The other good news is that no matter how poor you are at reasoning or solving abstract problems, you can still commit facts to long-term memory. Fluid intelligence governs how much information we can process at a given time, and because we can only remember what we think about, it stands to reason that those who think more quickly will end up remembering more. This does not imply that children with lower fluid intelligence cannot remember, just that they may need more repetition and patience. Happily, knowledge is cumulative: the more you learn about a subject, the easier it becomes to remember additional related items of knowledge.

The real benefits become clear when we understand that by improving crystallised intelligence we can 'hack' the limits of our fluid intelligence. For instance, if I know nothing about chess and try to memorise the positions of pieces on the board in Figure 5.2, the task is a formidable feat and I'll most probably give up.

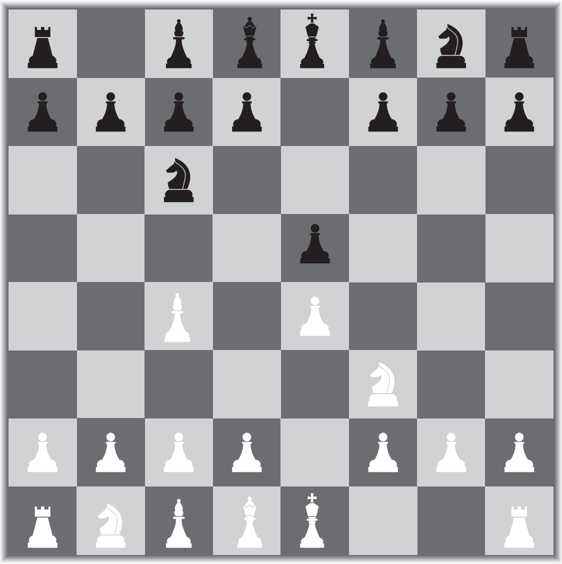

Figure 5.2. Chess position based on the Caro–Kann advance

However, if I already know the starting set-up of a chessboard then the task becomes much easier. Now, I only have to track which pieces have moved or are missing. And if I were a very experienced chess player, I might recognise this configuration as a variation of the Caro–Kann advance. In that case, the entire board becomes just a single item and the task becomes trivially easy. This is how crystallised intelligence acts upon the world.

We'll go on to explore the idea that knowing more makes us cleverer in greater depth. But, for now, let's draw together what we've learned so far in this chapter: that schools definitely seem to make us cleverer and that the way they achieve this is probably by increasing our crystallised intelligence. With this in mind, let's think about the startling discovery that IQ scores have been increasing massively over the past century.

Scientific spectacles

Back in the 1980s, intelligence researcher and political scientist James Flynn noticed something peculiar about the measurement of IQ. As we've already seen, IQ distributes normally across a population. What this means is that we can represent the intelligence of a large enough group of people with a bell curve (Figure 3.4 on page 71).

Average IQ is set at 100, with approximately 68% of people scoring within 15 points of the average mark and 96% within 30 points. If you're in the top 2% (with an IQ of 130 or above) you're in genius territory, and if you're in the bottom 2% you'll have trouble functioning in society. Because scores appear to be increasing over time, every now and then IQ tests have had to be recalibrated so that 100 continues to represent the average.

What Flynn noticed was that the average seemed to be steadily increasing. In fact, it's been going up by about 3 points per decade ever since the earliest years of testing.[19] We don't just get a few more questions right on IQ tests, we get far more questions right with each succeeding generation. On the face of it, this seems to suggest that we're all getting considerably cleverer. In fact, if you scored 100 on an IQ test and were somehow able to go back in time 50 years, you'd have an IQ of about 119. If you went back 100 years, you'd have a score of over 130 – better than nearly 98% of people alive at that time! And if that same time machine allowed an average person from 100 years ago to travel forward to us, their IQ score would now indicate mental retardation. Clearly, it's daft to suppose that the majority of people in previous centuries were retarded, and it's equally silly to think that most people alive today are geniuses. There must be another explanation for what's become known as the Flynn effect.

Various people have proposed various solutions to this enigma, including the idea that test questions have become common knowledge or that we've just got better at taking tests through practice. Weirdly, though, the biggest gains do not come from those questions that would seem to directly assess crystallised intelligence, like vocabulary and general knowledge. Rather, the questions we seem to score better on are mainly tests of abstract reasoning: similarities (What do caterpillars and tadpoles have in common?), analogies (ALL is to MANY as _____ is to FEW) and visual matrices (like Figure 5.1).

But it shouldn't take too much critical thinking to see that similarity and analogy sub-tests do test crystallised intelligence – we have to know what each of the items are before we can do much in the way of reasoning. And as Figure 5.3 shows, tests of general knowledge, vocabulary and mathematic ability have risen, but not nearly by as much. But if matrix reasoning tests are one of the best tests of fluid intelligence, how can we account for that increase? Answering this question will take some detective work.

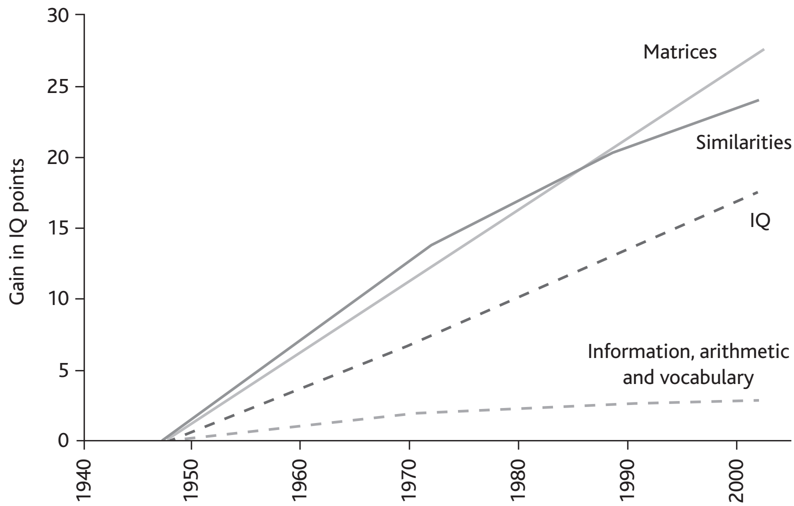

Figure 5.3. The Flynn effect: rising IQ scores, 1947–2002

Source: James R. Flynn, *What is Intelligence? Beyond the Flynn Effect* (Cambridge: Cambridge University Press, 2007), p. 6.

To say that the Flynn effect came as a surprise to the scientific community is something of an understatement. The one thing we can be clear about from the Flynn effect is that it's not caused by a change in our genes – evolution just doesn't work that quickly. As Sherlock Holmes tells us, "Eliminate all other factors, and the one which remains must be the truth."[20] So, if the rise in IQ isn't down to changes in the human genome, it must be something to do with the modern environment. It might seem reasonable to suggest that improved education and nutrition have played a part. Both are certainly correlated with rises in IQ, but no one is willing to accept they could account for a rise of 30 points over a century. As Neisser notes, "Whatever *g* may be, scores on tests that measure it best are going up at twice the rate of broad-spectrum tests … while the tests most closely linked to school content show the smallest gains of all."[21] On the face it, this is a bit of a puzzler. If general intelligence was rising, all sub-tests should have increased in proportion. If schools were causing the increase, vocabulary, arithmetic and general knowledge scores should have gone up by as much as other components.

However, *g* may be only one factor affecting intelligence. If we are to make sense of the Flynn effect we should also think about our cognitive environment. Flynn himself reckons that social pressures reward acquiring skill in certain areas disproportionately more than in others, and that the biggest social change over the period of these IQ increases has been the increasing tendency to view the world through 'scientific spectacles' and think in more abstract terms. He suggests that this social pressure has caused some cognitive attributes to "swim freely of *g*".[22] Although this is conjecture, I find Flynn's thesis compelling and it's currently the only one which adequately fits the facts.

Imagine, thousands of years in the future, archaeologists picking over the remains of our civilisation and finding evidence that people's ability to shoot had dramatically improved. In the 1860s people were getting one bullet on target, by the turn of the century this had gone up to five bullets in the bullseye and by 1918 people were averaging 100 bullets on target. What would they conclude? That our hand–eye coordination had undergone an unprecedented evolutionary surge? Or that gun technology had undergone rapid advances?

Over the past century, our minds have altered dramatically in the way they perceive the world, but this has nothing to do with evolution and everything to do with the remarkable technological advances we've seen in human culture. Flynn cites the research of the late, great Russian psychologist Alexander Romanovich Luria, who tested Russian peasants with the sort of questions commonly asked in IQ tests. When they were asked what a horse and a dog had in common they answered that both were used in hunting rather than classifying them both as mammals. When given the following scenario: "There are no camels in Germany. Hamburg is a city in Germany. Are there camels in Hamburg?" the reply was, "If Hamburg is a large city, there should be camels there." When challenged, one interviewee allowed that maybe Hamburg was a small village and so there would be no room for camels. Because he was used to seeing camels in villages he couldn't imagine a town of any size that did not contain the odd camel or two. He was unable to ask the hypothetical question, *What if there were no camels in Germany?*[23]

Flynn takes this as evidence that our experience shapes the way we think. If we spend our lives thinking about practical concerns, such as where our next meal is coming from, then we're much more likely to think in concrete terms about what immediately concerns us. Without direction, most educated people might struggle to see the connections made by Luria's subjects. But being familiar with scientific taxonomy and the kind of abstract thinking required to operate a computer is how we have trained ourselves to think. Human beings have, Flynn argues, shifted from being people who thought in predominantly concrete terms about what might benefit them in the immediate environment, to people who think primarily in abstractions.[24] In addition, many more people get a lot more schooling now than was the case in the past, and that schooling tends to focus on abstract thinking rather than concrete facts.

Consider these examples of exam questions for 14-year-olds from 1912:

- How long a rope is required to reach from the top of a building 40 ft. high, to the ground 30 ft. from the base of the building?
- What properties have verbs?
- Diagram*: The Lord loveth a cheerful giver.
- Tell what you know of the Gulf Stream.
- Locate the following mountains: Blue Ridge, Himalaya, Andes, Alps, Wasatch.
- Name and give boundaries of the five zones.
- How does the liver compare in size with other glands in the human body? Where is it located? What does it secrate?
- Name the organs of circulation.
- Name and define the three branches of the government of the United States.

* Sentence diagramming is a way of dividing a sentence up into parts of speech.

- Describe the manner in which the president and the vice-president of the United States are elected.
- During what wars were the following battles fought: Brandywine, Great Meadows, Lundy's Lane, Antietam, Buena Vista.
- Who invented the following: Magnetic Telegraph, Cotton Gin, Sewing Machine, Telephone, Phonograph.[25]

With the exception of the maths questions, children today tend not to learn this kind of information. Research systematically documenting the content of school exams between 1902 and 1913, comparing them to similar exams in the 1990s, found that when it comes to factual knowledge, far less is expected of modern students. Instead, they are more likely to be taught transferable skills which, it is hoped, they will be able to apply in a range of contexts.[26] As we've seen, there is reason to doubt that such skills actually transfer in any meaningful way. The consequence may be that we are better at hypothetical and abstract thought, but know much less.

So, have we actually become cleverer, or have we just improved at the kinds of thinking measured by IQ tests? It should be obvious that any rise in IQ scores does not mean that people living today are cleverer in any functional sense than our ancestors. People in the past thought in ways that were suited to the world in which they lived, and so do we. You might think this is a bit of a trick and evidence that IQ tests don't actually measure anything important, but it turns out that the kind of thinking that allows us to do better in IQ tests has important real-world applications. The ability to divide the world into scientifically useful classifications, think hypothetically and frame our thoughts in abstract, universal terms seems to lead to us making better moral decisions.

Flynn notes that our ability to take universal and hypothetical statements seriously has changed the way we think. He argues that changes in the way we reason have improved the quality of moral debate. He recounts trying to confront his own father's racial bias by asking, "But what if your skin turned black?" In response, his father, a man born in 1885, would reply by saying, "That is the dumbest thing you've ever said – whom do you know whose skin has ever turned black?"[27]

If you can't take seriously the idea that you could be black, then you are less able to empathise. If you can universalise your moral principles and see how they would apply to other people in other situations, then you are more likely to make better decisions. Stephen Pinker speculates that this may have led to a moral Flynn effect, "in which an accelerating escalator of reason carried us away from impulses that lead to violence".[28] He reviews the fact that consensus attitudes towards ethnic minorities and women 100 years ago are considered disgustingly immoral by today's standards. We find it hard to imagine that Thomas Jefferson was a slave owner, that Theodore Roosevelt described Native Americans as "squalid savages",[29] that Woodrow Wilson was an admirer of the Ku Klux Klan[30] or that Winston Churchill could describe Indians as "a beastly people with a beastly religion".[31] Such sentiments are now so beyond the political pale that to most people they are unthinkable, let alone unsayable. It wasn't just politicians who thought this way, many writers including T. S. Eliot, D. H. Lawrence, Virginia Woolf, George Bernard Shaw and Gustave Flaubert expressed similarly contemptible racist ideas.[32]

Has our growing fluency with abstract reasoning and hypothetical thinking helped us to overcome such prejudice? Well, as recent elections in Europe and the United States have demonstrated, racism is alive and well, although it is perhaps more muted and far less mainstream. More tellingly, we know that the higher your IQ, the less likely you are to commit violent crime,[33] the more inclined you are to cooperate with others[34] and more likely you are to be politically liberal.[35] This is just the beginning of a long list of correlations between higher intelligence and more moral behaviour that Pinker elucidates in *The Better Angels of Our Nature*.[36] Of course, none of this should be taken as proof that making kids cleverer will result in a safer, fairer society, but it seems a good bet.

There is, however, a potential downside to all this. Even if the ability to think hypothetically generally allows us to be more empathetic, the fact that children are often ignorant about the facts of the world in which they live severely curtails their ability to think rationally. If today we are unable to answer questions like those on pages 126–127, then we are unable to think about those things. The implications for this will become clearer in later chapters.

Some scientists have argued that the Flynn effect may be coming to an end. They point to the fact that the rise in IQ in undeveloped countries is far steeper than that in the developed world.[37] Other reviews suggest that the Flynn effect shows no immediate signs of petering out, even in the most developed countries.[38] Whatever the cause – and Flynn's idea of 'scientific spectacles' seems as good an explanation as any – it may be slowing down but, despite some evidence to the contrary, it doesn't seem to be going away.*

Four legs growth, two legs fixed

Perhaps the most popular of the current approaches to raising children's intelligence is Carol Dweck's growth mindset – the idea that we can become cleverer by *believing* we can become cleverer. This is a beguiling idea, but is it more than just wishful thinking? After all, if wishes were fishes we'd all have salmon for supper. Obviously, no one becomes an astronaut just because they believe they can. This is mindset-lite: the undifferentiated and naive belief that the right kind of thinking leads to wonderful things. Like most well-intentioned educational fads, there's a kernel of truth in these sorts of claims. Hard work *does* make a difference; beliefs *do* matter. As always, though, reality is a little more complicated.

Dweck argues that how children attribute their successes and failures affects how they respond to the challenges and obstacles they face in life. Some people possess an 'incremental theory' of intelligence – what has become known as a growth mindset. This means they tend to see ability as something that can be increased with effort and time. Others possess an 'entity theory' of intelligence – a fixed mindset – and see ability as something that is static and inflexible. Children with a growth mindset generally focus on learning goals and are more willing to take on challenging tasks in an effort to test and expand rather than defensively prove their intelligence or ability. Hence, they rebound more easily from negative feedback and failure. Accordingly, if you believe that your intelligence and ability can be enhanced, you will tend to perform better on a variety of cognitive tasks and in problem-solving situations. Whenever we fail at something we look for reasons. If those reasons are seen as within our power to change ("I didn't try hard enough") then we can do something

* A recent study of 730,000 Norwegian men born between 1962 and 1991 has shown that IQ scores peaked in 1975 and then declined at a rate of about 7 points a generation. The researchers have speculated that this decline could be due to falling educational standards and screen-based entertainment. See Bratsberg and Rogeberg (2018).

about it, but if we find reasons that are outside of our sphere of control ("I'm not clever enough") then we're stuffed. It should go without saying that we will be better able to cope when our failure is attributed to lack of effort rather than to lack of ability.

This is not entirely uncontroversial. As we shall see, other studies have been unable to replicate Dweck's original results, finding instead that if students with a growth mindset were overly concerned with academic performance they tended to behave similarly to those students with a fixed mindset.[39]

To find out what kind of mindset you have, Dweck has devised a series of statements like, "You can always substantially change how intelligent you are", to which you respond by saying whether you agree or disagree.[40] Not only are these sorts of self-report surveys notoriously unreliable,[41] there is also a question as to whether we have the same mindset across all subjects and challenges, or whether we adopt a fixed mindset for some things and a growth mindset for others. Most of us cut our losses and give up on some things in order to improve on others. It may be that a fixed mindset about, say, our ability to perform quadratic equations, saves us from a good deal of frustration and wasted time. In essence, the fixed mindset may be an adaptive response – an evolved strategy preventing us from wasting effort where we have experienced frequent failure and where the opportunity for future success is low.

But what if we could change our mindset? Dweck makes some pretty bold claims:

> We found that if we changed students' mindsets, we could boost their achievement. More precisely, students who believed their intelligence could be developed (a growth mindset) outperformed those who believed their intelligence was fixed (a fixed mindset). And when students learned through a structured program that they could 'grow their brains' and increase their intellectual abilities, they did better. Finally, we found that having children focus on the process that leads to learning (like hard work or trying new strategies) could foster a growth mindset and its benefits.[42]

No one would deny that hard work and learning new strategies make a huge difference to how well children perform academically, but hard work and a growth mindset are not enough. In fact, it seems likely that practising more without getting results will probably erode beliefs about self-efficacy. No wonder children learn that they 'can't do maths' or that 'French is impossible' if they're practising in the wrong way. If we believe that the difference between successful and unsuccessful students is their mindset then we could be adding to a potentially toxic cocktail. It's much more likely that a growth mindset follows from experiencing success. If we get good early results then our self-confidence can become invincible, but if we don't … Well, only a fool continues to believe anything is possible in the face of increasingly contradictory evidence. Dweck acknowledges this problem: "Students need to know that if they're stuck, they don't need just effort. You don't want them redoubling their efforts with the same ineffective strategies. You want them to know when to ask for help and when to use resources that are available."[43]

But what about the idea that we can grow our brains? Can such an approach really increase our intellectual ability? One of the central claims made by growth mindset proponents is that "the brain is like a muscle".[44] It's not. For this to be true the brain would have to behave like a leg: if you exercise your leg muscles, you get better at everything you use your legs for. The same muscle groups are used whether you're running, jumping, dancing or sitting in the full lotus position. The claim that the brain is like a muscle supposes that doing one kind of mental exercise would make you better at every other kind of mental exercise. The economist Bryan Caplan argues that this claim is improbable:

> You don't exercise your legs to improve your bench press. You don't even exercise your right leg to strengthen your left leg. Instead, you exercise the muscles you seek to build. Why would 'mental muscles' be any less specific? Furthermore, when you stop going to the gym, your physical muscles soon atrophy. Why would 'mental muscles' be any slower to wither?[45]

And, as we shall see, empirical evidence doesn't really support such a claim either.

Another common claim is that "mistakes make your brain grow".[46] In interviews, Jo Boaler – professor of mathematics education and Dweck devotee – cites research indicating that whenever we make a mistake a synapse fires. But if you didn't know you had made a mistake how would a synapse know to fire? Moreover, it's not at all clear that a synapse firing is the same as your brain growing.

The research Boaler refers to details an experiment conducted by Jason Mosel and his colleagues in which 25 participants were wired up with electrodes and asked to spot whether a string of five letters were all the same (congruent) or whether the central letters were different (incongruent). For instance, the string 'MMMMM' is congruent and 'NNMNN' is incongruent. In order to make it more challenging, participants saw each string for less than a second. Mosel established whether participants had a growth or a fixed mindset by asking them to respond to statements such as, "You have a certain amount of intelligence and you really cannot do much to change it." The survey results were then cross-referenced with the results of the electrical activity recorded when the subjects made a mistake on the test. They found that those participants who were identified as having a growth mindset showed more electrical activity of the type they were looking for than did those with a fixed mindset.[47] What should we conclude from this?

The first problem is that Mosel and colleagues only measured the types of electrical activity known to occur when mistakes are made, but nothing else. We have no idea what they might have found if they had looked for something else. Secondly, it's not clear that electrical activity is in any way synonymous with brain growth. Thirdly, the questionnaire used to establish the subjects' mindset seems like an absurdly blunt instrument (indeed, Dweck herself has said, "Everyone is a mixture of fixed and growth mindsets"[48]). Finally, the type of test used in the experiment – one where participants had no problem knowing if they were right or wrong – is a far cry from the sorts of situations in which people are likely to find themselves in real life. This seems like scant evidence to support the claim that our brains grow when we make mistakes.

Although Dweck's claims appear to rest on solid empirical foundations, there are some concerns that we should address. Mindset theory makes several falsifiable predictions:

1. Having a growth mindset towards academic study leads to better academic achievement.

2. Having a fixed mindset towards academic study leads to poorer academic achievement.

3. Giving students a growth mindset intervention (which focuses on explaining the neuroscience involved) improves students' academic performance.

Dweck's studies, and those of her colleagues, provide impressive data, but – and it's a big but – when schools try to implement a growth mindset intervention it often doesn't work. Maybe you've tried telling kids about growth mindset and how this can turn them into academic superheroes? Has it worked? If it has, great. If it hasn't, the problem might be that either you or your students have a 'false growth mindset'.

Dweck talks about the false growth mindset as a way of explaining away some of the difficulties I have with her theories. Basically, if you don't get the benefits of a growth mindset it's because you haven't really got a growth mindset. You're doing it wrong. In fact, you're probably just pretending to have a growth mindset because having a fixed mindset means you're a bad person.[49]

As we saw in our discussion of multiple intelligences, the problem with a theory that explains away all the objections is that it becomes unfalsifiable. There are no conditions in which the claim could not be true. For instance, when fossil evidence disproved the widely believed 'fact' that the world was created in 4004 BC, Philip Henry Gosse came up with the wonderful argument that God created fossils to make the world look older than it actually was in order to fox us and make Himself appear even more fabulous and omnipotent.[50] Adjusting the definitions of your theory in order to fit the facts is a hallmark of pseudoscience. If no amount of data or evidence can prove Dweck's claims false, isn't mindset theory unfalsifiable?

Perhaps this explains the trouble other researchers have had in replicating Dweck's findings. The Education Endowment Foundation's *Changing Mindsets* report found no statistically significant evidence of impact,[51] and in 2017, Yue Li and Timothy Bates forensically recreated Dweck's experiments and found no correlation between mindset interventions and improvements in students' performance. They say, "Mindsets and mindset-intervention effects on both grades and ability, however, were null, or even reversed from the theorised direction. … This contradicts the idea that beliefs about ability being fixed are harmful."[52]

Dweck is dismissive of the idea that her research might be easy to replicate:

> We put so much thought into creating an environment; we spend hours and days on each question, on creating a context in which the phenomenon could plausibly emerge … Replication is very important, but they have to be genuine replications and thoughtful replications done by skilled people. Very few studies will replicate done by an amateur in a willy-nilly way.[53]

This is the Bargh fallacy – the phenomenon of original authors calling researchers who try (and fail) to replicate their work 'amateurs'. This fallacy takes its name from psychologist John Bargh who launched a scathing personal attack on researchers who had failed to replicate a version of stereotype threat which found that older people performed worse in tests when primed to think about their age.[54] Not only is this bad science, it's also self-defeating. If it's true that replicating Dweck's studies takes "hours and days" to create the right context and cannot be done by amateurs "in a willy-nilly way", then what chance does your average teacher have? Despite the widespread appeal of mindset theory, the US study *Mindset in the Classroom* suggests that over 80% of teachers who have attempted to implement Dweck's suggestions have failed to make effective changes in their classrooms.[55]

Another study of the effects of growth mindset interventions on students' grade point averages in the United States had a huge sample of over 12,500 students in 65 different schools. It found that the "intervention reduced by 3% the rate at which adolescents in the U.S. were off-track for graduation at the end of the year".[56]

This sounds like good news but, as ever, we should proceed with caution. The study appears to show that giving students two 25-minute sessions on how the brain forms synaptic connections when we struggle has a small but real effect on students' outcomes for a very low cost. The authors also note that some students benefitted far more than others, and those who seemed to benefit most were lower achieving students and students in schools with "supportive behavioral norms". What this might suggest is that students who have previously underachieved improve when told that if they take more responsibility and work harder they might do better and that good behaviour makes a positive difference to any intervention, neither of which are all that surprising.

Were the results down to students believing that basic ability is malleable, or is it that working harder improves results? The first option – the growth mindset hypothesis – asks us to believe in magical thinking, whereas the second is about how conscientious we are. Beliefs about the malleability of basic ability appear to be largely irrelevant: achievement is all about work. Sadly, although the study reports that growth mindset interventions work, there's no way to determine what is actually affecting results.

More evidence comes from two meta-analyses into the circumstances in which growth mindset interventions are effective. Researchers examined the strength of the relationship between mindset and academic success and found that "Overall effects were weak for both meta-analyses. However, some results supported specific tenets of the theory, namely, that students with low socioeconomic status or who are academically at risk might benefit from mind-set interventions."[57]

Again, this sounds like it might be positive, but over 40 individual studies into the effects of mindset interventions reveal something of a mixed picture. We can summarise the main findings thus:

1. The correlation of growth mindset interventions with achievement is small (correlation = 0.1).
2. The effect of growth mindset interventions on achievement is also very small (an effect size of = 0.08).*
3. While 86% of interventions had an impact, this was almost as likely to be negative as positive.

Researchers concluded that it's worth giving students from lower socioeconomic status backgrounds, or who those who are academically at risk, 50 minutes' worth of cartoons about synapses and brain cells. Maybe. But we should also reflect on the fact that, as things stand, there's no reason to believe that spending any more time on this sort of intervention is likely to be worthwhile. If nothing else, we should take away the well-worn truths that well-behaved students in orderly, supportive environments, and students who understand the relationship between effort and outcomes, do better than those who don't.

* In fairness, Dweck refutes this, saying, "These effects don't look so small when you use the right comparisons" (Dweck, 2018) .

What ought to be obvious to anyone who has spent any time reflecting on their own habits and behaviour is that we all try hard at things we believe we are good at, and we all quit things we think we suck at. This is human nature. If we're serious about changing children's beliefs about their ability, we ought to commit far more time to ensuring they can be successful at the subjects we teach.

To be clear, I'm not saying that growth mindset is wrong or useless, but it does contradict research in other fields. It also flies in the face of many people's lived experience: there really are people with fixed mindsets who are actually very successful and not helpless at all.

Can you train your brain?

Earlier in this chapter, we explored the differences between fluid and crystallised intelligence and established that while crystallised intelligence (the ability to retrieve and apply information stored in long-term memory) can be improved relatively straightforwardly by teaching children knowledge and then giving them practice in retrieving and applying this knowledge in a variety of contexts, fluid intelligence is well correlated with working memory capacity and appears to be fixed. This is a shame because, as cognitive scientist Daniel Willingham says:

> The lack of space in working memory is a fundamental bottleneck of human cognition … if a genie comes out of a lamp and offers you one way to improve your mind, ask for more working memory capacity. People with more capacity are better thinkers, at least for the type of thinking done in school.[58]

Does such a genie exist? Is there evidence that we can, in fact, increase fluid intelligence through specialised 'brain training' programmes? Some people certainly think so. For instance, Robert Sternberg argues that "Fluid intelligence is trainable to a significant and meaningful degree."[59]

Sternberg was writing about a 2008 study conducted by Susanne Jaeggi and colleagues which claimed to show evidence that practice at brain training games transfers to increases in fluid intelligence:

> This transfer results even though the trained task is entirely different from the intelligence test itself. Furthermore, we demonstrate that the

> extent of gain in intelligence critically depends on the amount of training: the more training, the more improvement in Gf [fluid intelligence].[60]

Sounds encouraging, doesn't it? Sternberg certainly thought so. He suggested that Jaeggi's results had "important educational-policy implications, because they suggest that the results of conventional tests of intellectual abilities and aptitudes provide indices that may be dynamic rather than static and modifiable rather than fixed".[61]

Practising mental arithmetic improves your ability to do mental arithmetic. Similarly, if you practise memorising the order of a deck of shuffled cards you will get better at that, and if you practise playing brain training games you can become significantly better at playing brain training games. But these improvements don't seem to transfer to everyday measures of intelligence. The specific claim of Jaeggi's research is that, by engaging in a specialised form of brain training programme, an increase in working memory capacity can be *transferred across domains*. This flies in the face of everything we know about our ability to transfer skills across unrelated domains.[62] If Jaeggi were right, it would make sense for schools to focus on brain training programmes.

David Moody throws cold water on these hopes: "A close examination of the evidence reported by Jaeggi et al. shows that it is not in fact sufficient to support the authors' conclusion of any increase in their subjects' fluid intelligence." Moody is critical of the way in which the tests were designed and administered, and points out that far from the training exercises being entirely different from the tests, some actually seem to have been specifically designed to help subjects perform better on final tests. He concludes by saying, "Whatever the meaning of the modest gains in performance … the evidence produced by Jaeggi et al. does not support the conclusion of an increase in their subjects' intelligence."[63]

This is a debate that has rattled on and on. A 2013 report concluded: "It is becoming very clear that training on working memory with the goal of trying to increase fluid intelligence will likely not succeed."[64] Whereas in 2014, a team (including Jaeggi) which conducted a meta-analysis into improving fluid intelligence with training on working memory found that "it is becoming very clear to us that training on [working memory] with the goal of trying to increase fluid intelligence holds much promise".[65] All this is anything but clear.

Most recently, a comprehensive review by Daniel Simons and colleagues attempted to put the matter beyond doubt. They found "little evidence that training enhances performance on distantly related tasks or that training improves everyday cognitive performance". They also pointed out that most of the studies showing the effectiveness of brain training games were poorly designed "and that none of the cited studies conformed to all of the best practices we identify as essential to drawing clear conclusions about the benefits of brain training for everyday activities".[66]

To the best of our current knowledge, brain training games make you better at brain training games, but they don't seem to result in a generalisable increase in working memory capacity and do not increase fluid intelligence.[67]

Let's think about thinking skills

It's very tempting to believe that if we teach children how to think, they will think better. After all, when we teach children to read, they read better and when we teach them to juggle, they get better at juggling. Why should thinking be any different?

Well, first we have to identify what we mean by thinking. There are two common usages of the term: one holds that thinking is everything the conscious mind does. This would include perception, mental arithmetic, remembering a phone number or conjuring up an image of an elephant-headed zebra. The second use of the word covers the many varieties of unconscious thought. These unconscious cognitive processes are doubtless tremendously important in shaping the way we make sense of the world but, fascinating as the unconscious mind is, this is beyond the scope of this book.

Simply equating thinking with any and all conscious cognitive processes is too broad to be useful. I discuss thinking as an essentially active process and therefore distinct from the more passive 'thought'. Thought is the product of thinking and thinking is the process of getting from A to B. So, for our purposes, thinking is both conscious and active. It is the kind of deliberative cognitive process that can make new connections and create meaning.

So, what might a 'thinking skill' be? Depending on who you ask, you get stuff like this:

- Organising gathered information.
- Forming concepts.
- Linking ideas together.
- Creating, deciding, analysing and evaluating.
- Planning, monitoring and evaluating.[68]

The thing is, these skills are worthless unless tied to a body of knowledge. In order to organise information, for example, you must have some information to organise, but organising information is something we do automatically. Likewise forming a concept. A concept is formed out of what we know, and again our minds appear to be wired in order to make forming concepts easy. As an intellectual exercise – practising thinking skills, if you will – why not work your way through the rest of the list and suggest how any of these items could possibly exist in the absence of propositional knowledge.

As we saw in Chapter 2, we all possess an evolved capacity to readily learn these things. We're born with the ability to organise environmental stimuli into schemas, which then form concepts and categories and so forth. We do this unconsciously without the need for thought. Other things like planning and evaluating also happen unconsciously, but we can also decide to pay additional attention when our experience is such that we're not sure as to outcomes. It might be useful to prompt children to do these things and briefly demonstrate how to do them, but investing much more time than that is likely to run into a considerable opportunity cost (see page 216).

The idea that thinking skills taught in one context will transfer to other unrelated contexts is one of the holy grails of education. But the evidence is not positive. Such transfer rarely, if ever, occurs. Bryan Caplan says that "Though some educational psychologists deny that education *must* yield minimal transfer, almost all admit that actually existing education does yield minimal transfer." He points out that teachers' claims of being good at teaching transferable thinking skills are "comically convenient" and that "When someone insists their product has big, hard-to-see benefits, you should be dubious by default – especially when the easy-to-see benefits are small."[69]

However, if you want to, you can take an A level course in thinking skills.[70] The skills assessed in this course are our old friends problem solving and critical thinking, as well as 'problem analysis and solution' and 'applied reasoning'. Now, of course, you can learn a body of knowledge which includes recognising and identifying biases, questioning assumptions and identifying logical fallacies. These are things everyone would probably benefit from learning about, and they will, no doubt, increase your crystallised intelligence. However, as we've seen, although we can measure raw reasoning power (fluid intelligence), to the best of our knowledge there is nothing we can do to increase it.

Here's the sort of question that might crop up on a thinking skills exam paper: "If P is true, then Q is true. Q is not true. What, if anything, follows?" The idea is that you need no prior knowledge to answer such a question, but, of course, that's absurd. If you've encountered this sort of logical problem before, your experience will be a great advantage. This is a product of crystallised intelligence. Some of the questions on the thinking skills paper are more insensitive to instruction than others,[71] but that just means there's little gain in teaching thinking skills beyond a certain point. Exposure to, and practise at, these kinds of questions improves our ability to answer them but, ultimately, some people are just better at reasoning than others.

But what about cognitive acceleration – specifically Cognitive Acceleration through Science Education (CASE)?[72] The basis of the CASE intervention requires a mediator to ask questions that allow 'guided self-discovery' with children working together in groups to solve a problem. The claim made by Philip Adey and Michael Shayer is that by teaching their science course to 12-year-olds, their English language GCSE results were improved at age 16.[73] Too good to be true? If it were true it would contradict decades of research in cognitive science and be the ultimate vindication for proponents of discovery learning and group work.

In 2016, a randomised controlled trial funded by the Education Endowment Foundation was unable to replicate the miraculous findings documented by Adey and Shayer. In fact, the conclusions drawn by the research team were that there was "no evidence that Let's Think

Secondary Science [LTSS] improved the science attainment of children by the end of Year 8". Furthermore, "Children who received LTSS did worse than the control group on the English and maths assessments", although they do allow that "this result could have occurred by chance and we are not able to conclude that it was caused by the programme".[74] Not only was there no effect of cognitive acceleration programmes on science, there was also no evidence of far transfer.

Despite a significant investment in tailored training, the Education Endowment Foundation noted that "Many schools did not implement the programme as intended by the developer", which can be a problem with educational interventions that teachers find difficult to deliver. It may be that CASE – or Let's Think Secondary Science as it's now branded – is actually wonderful and the poor results are just the fault of incompetent teachers messing up the researchers' hard work, but, equally, it may be that if the interventions are so hard to get right then they are not worth considering.

If we are to accept that something as implausible as minimally guided group work in science leads to far transfer years later in unrelated domains, then we need a spectacularly good reason to do so. This has become known as the Sagan Standard, named after the astronomer and science writer Carl Sagan, who said: "Extraordinary claims require extraordinary evidence."[75]

Psychology professor Douglas Detterman relates his personal journey to the depressing realisation that transfer doesn't just happen:

> When I began teaching I thought it was important to make things as hard as possible for students so they would discover the principles for themselves. I thought the discovery of principles was a fundamental skill that students needed to learn and transfer to new situations. Now I view education, even graduate education, as the learning of information. I try to make it as easy for students as possible. Where before I was ambiguous about what a good paper was, I now provide examples of the best papers from past classes. Before, I expected students to infer the general conclusion from specific examples. Now I provide the general conclusion and support it with specific examples. In general, I subscribe to the principle that you should teach people exactly what you want them to learn in a situation as close as possible to the one in which the learning will be applied. I don't count on transfer and I don't try to promote it except by explicitly pointing out where taught skills might be applied.[76]

Although I've take a couple of swipes at Detterman in previous chapters, in this respect his journey precisely mirrors my own. The irony is that both he and I had to discover the principle for ourselves. In my case this took 15 years of frustration. How much better would it have been for us, and our students, if someone had simply told us what we needed to know? But would we have believed them if they had?

David Ausubel, also a professor of psychology, is similarly sceptical:

> ... it hardly seems plausible that a strategy of inquiry that must necessarily be broad enough to be applicable to a wide range of disciplines and problems can ever have, at the same time, sufficient particular relevance to be helpful in the solution of the specific problem at hand.[77]

If 'thinking skills' are a body of knowledge that adds to crystallised intelligence, thereby making us better thinkers, then, yes, of course we can teach them. But let's not assume that such skills are likely to have any effect beyond this. We should only teach things because we value them in and of themselves. By all means teach children chess or the music of Mozart, but don't bother if you only hope it will make them better thinkers. If you're still convinced of the plausibility of transfer between unrelated domains then I have some magic beans you might be interested in …

Is ability grouping a good idea?

Does putting bright children in elective environments work? In Chapter 4, we concluded that academic selection is unlikely to have more than a marginal benefit for the most fortunate and is likely to reduce the intelligence of the less fortunate. But is the same true of segregating children by ability within schools? The evidence on ability grouping is relatively well known. The Education Endowment Foundation Toolkit summarises the research findings thus:

> Overall, setting or streaming appears to benefit higher attaining pupils and be detrimental to the learning of mid-range and lower attaining learners. On average, it does not appear to be an effective strategy for raising the attainment of disadvantaged pupils, who are more likely to be assigned to lower groups.[78]

It appears that children who are deemed to be 'low ability' fall behind pupils with equivalent prior attainment at the rate of between one and two months per year when placed in ability groups. Conversely, high attainers make, on average, an additional one to two months' progress per year when they are set.

There's much speculation about why this is the case. It could be that low ability groups are assigned less capable teachers. Top sets are often seen as a reward, bottom sets as a punishment. If low attainers are viewed as unlikely to make good progress then it might not make strategic sense to assign them your best teachers. A second explanation is that behaviour in bottom sets prevents children from learning. If so, it's scandalous that some schools continue to allow classes for lower ability children to be sinks of low expectations and poor behaviour. This leads to another possibility: when children are corralled together by ability, they learn that they are either 'bright' or 'thick' and then rise or sink to meet these expectations.

It's no surprise that we usually experience what we expect to experience. Most likely, you're already aware of the placebo effect – the phenomenon in medicine that an inert tablet triggers a psychological response, which in turn impacts, usually positively, on a patient's health. Research into the placebo effect has focused on the relationship between mind and body. One of the most common theories is that physical responses may be due to our expectations: if we expect a pill to do something, then it's possible that our body's chemistry can trigger effects similar to those the actual medication might have caused. It seems reasonable to suggest that a child's belief about their learning could be influenced in a similar way.

We should also be aware of the Pygmalion effect. According to legend, Pygmalion invested so much love and care in sculpting a statue of the most beautiful and inspiring woman he could imagine that he fell in love with it. Too ashamed to admit he'd fallen for a statue, he prayed for a bride who would be a living likeness of his impossibly beautiful sculpture. The gods granted his wish and the statue became flesh.

Pygmalion's unreasonably high expectations for the woman of his desires resulted in him getting what he wanted. Likewise, teachers' expectations can be a self-fulfilling prophecy. Our beliefs about children have a tremendous impact on their progress and attainment. The self-defeating corollary of the Pygmalion effect is the Golem effect – the idea that negative expectations lead to decreases in performance. Robert Rosenthal and Lenore Jacobson's landmark 1968 experiment demonstrated that if teachers were led to expect enhanced performance from certain children, then the children's performance was indeed enhanced. In the study, children were given a disguised IQ test and teachers were told that some of their students (about 20% of the cohort, chosen at random) would be, in Rosenthal and Jacobson's rather unfortunate turn of phrase, 'spurters', and likely to make sudden and rapid progress over the following year. At the end of the study, all children were re-tested and the results showed statistically significant gains favouring the experimental group. The spurters had spurted. The conclusion is that teachers' expectations can have a strong influence on students' achievement.[79]

And so they can, but maybe not as much as is commonly believed. Lee Jussim and Kent Harber argue that teacher expectancy effects may be overstated: "Self-fulfilling prophecies in the classroom do occur, but these effects are typically small, they do not accumulate greatly across perceivers or over time, and they may be more likely to dissipate than accumulate."[80] They conclude that there appears to be a high degree of correlation between teacher expectations and reality; maybe the reason our expectations come true is because they're accurate.

Instead of teacher expectations, maybe it's actually children's experiences in school *causing* differences in ability. Graham Nuthall puts it like this: "Ability appears to be the consequence in differences of what children learn from their classroom experience."[81] It's a fascinating idea that our intelligence is the consequence, not the cause, of what happens to us. It may not be completely true, but as we've seen, genes interact with the environment and small initial differences get larger over time. Nuthall's hypothesis may be the one most likely to lead to equitable experiences for all children.

As we will go on to establish in later chapters, the biggest and most important individual difference between children is the quality and quantity of what they know. Let's imagine a scenario where two students – Katie and Liam – join school mid-year and need to be placed into sets. Katie has experienced successful phonics teaching and mastered decoding in her first year of school, moving quickly to more interesting and sophisticated reading material. Liam, on the other hand, suffered with undiagnosed glue ear and was unable to properly make out the fine distinctions between different vowel and consonant sounds.* Although he can decode, his ability is halting and laborious. Too much of his fragile working memory capacity is spent on sounding out letters, with little left to spare for much in the way of higher level comprehension. Both pupils are assessed using a reading comprehension test; Katie scores well, while Liam does poorly. As a result, Katie is placed in the 'top set' and Liam in the 'bottom set'. While on the face of it this appears entirely reasonable, it could be the case that Liam is actually more intelligent than Katie but just knows less.

This might sound far-fetched, but Dylan Wiliam estimates that when tests are used to select children for ability groups "only half the students are placed where they 'should' be" (see Table 5.1).[82]

Table 5.1. Accuracy of setting with a test of validity of 0.7

		Should actually be in			
		Set 1	Set 2	Set 3	Set 4
Students placed in	Set 1	23	9	3	
	Set 2	9	12	9	
	Set 3		9	7	4
	Set 4		4	4	7

Source: Dylan Wiliam, Reliability, Validity, and All That Jazz, *Education 3–13* 29(3) (2001): 17–21 at 19.

There's no doubt that some children are more intelligent than others, but that doesn't mean teachers are especially good at identifying which children are more or less able, and it could be that schools are creating

* According to various sources, including NHS Direct Wales, "It's estimated that one in five children around the age of two will be affected by glue ear at any given time, and about 8 in every 10 children will have had glue ear at least once by the time they're 10 years old."

self-fulfilling prophecies by ensuring that some children learn less than others.

Let's return to our fictitious students. In the top set, Katie is given more challenging material at a faster pace. Her early advantage is compounded. Liam is given simpler things to do at a slower pace, ensuring that, relatively speaking, he knows less and less. The more we know, the more we can think about and the cleverer we become. This is yet another example of the Matthew effect: the rich seem to get richer while the poor get poorer. Of course, this poverty is comparative not absolute. No one is actively stripping away what children know, but through low expectations and faulty understandings those who most need to progress are stymied and cast adrift on a sea of chance. Children's experiences in school determine, to a large extent, their ability. After all, no one rises to a low expectation.

Of course, as I keep accentuating, none of this is fate; the research reports what has been, not what could be. Conceivably, a school could design an approach to setting in which middle and low attainers are not held back, but we can be reasonably sure of what is likely to happen to children if a school's approach to setting is broadly similar to those that have gone before.

If we're interested in making all children cleverer, we should delay grouping pupils by ability for as long as possible. If some children are holding back the progress of others because they have not mastered basic, foundational knowledge – such as how to decode text at a minimum of 200 words per minute – they can and should be taught what they need to know as an intervention and then returned to normal lessons.*

…………………………………….

To summarise this chapter, the scientific-sounding claims of brains growing when mistakes are made, and the efficacy of brain training, thinking skills and cognitive acceleration are seductive. No doubt there will be many more pitfalls and false starts, and no small amount of snake oil to add to other failed theories of increasing intelligence – such as playing chess, listening to Mozart and taking fish oil supplements. The truth is

* See James and Dianne Murphy's book *Thinking Reading* for clear and practical guidance on how to achieve this.

more mundane and less sciency, but there are excellent reasons to believe that we can all get cleverer than we are currently by enlarging our store of knowledge, thereby increasing our crystallised intelligence.

Chapter 5: key points

- The longer children stay in school, the cleverer they get.
- Intelligence is made up of fluid and crystallised intelligence. While we probably can't increase our fluid intelligence, crystallised intelligence is highly malleable.
- Crystallised intelligence is the ability to apply stored knowledge. If children know more then they will be cleverer as a result.
- The past century has seen massive average IQ gains. This is probably attributable to the modern need to think more hypothetically and abstractly.
- Raising intelligence is a social as well as an individual good: the cleverer we are, the more likely we are to make better moral decisions.
- Too many approaches in education disproportionately benefit children with higher fluid intelligence and those from advantaged socio-economic backgrounds, whereas a focus on increasing crystallised intelligence would disproportionately benefit the least advantaged.
- Having a growth mindset may not have much impact on our intelligence or academic outcomes.
- Playing brain training games only makes us better at brain training games.
- Thinking is not generic and so attempts to develop thinking skills are unlikely to make much difference.
- Ability grouping can become a self-fulfilling prophecy. What we experience in school is the cause, not the consequence, of our academic ability.

The more knowledge we have at our disposal, the easier we will find it to make new connections and solve problems we recognise. This thinking is inextricably bound up with what we know, therefore the next step is to consider how we come to know things. What we know is broadly synonymous with what we remember and so, in the next chapter, we turn our attention to memory.

Given the choice, who wouldn't want to be cleverer? What teacher wouldn't want this for their students, and what parent wouldn't wish it for their children?

When David Didau started researching this book, he thought the answers to these questions were obvious. But it turns out that the very idea of measuring and increasing children's intelligence makes many people extremely uncomfortable. They think, "If some people were more intelligent, where would that leave those of us who weren't?"

Writing in his inimitable, thought-provoking style, David reignites the nature vs. nurture debate around intelligence and offers research-informed guidance on the practical things teachers can do to narrow the attainment gap, and to help all children acquire a robust store of powerful knowledge, as well as the skills to make use of it.

Schools and parents alike invest so much energy in teaching children and yet often understand relatively little about what exactly it is they are trying to achieve. In *Making Kids Cleverer* David Didau reviews everything we know from cognitive science on how to enhance children's learning, and delivers a powerful argument that we can – and must – help all children succeed at school.

Rebecca Allen, Professor of Education, University College London Institute of Education

David Didau has done it again! *Making Kids Cleverer* is an engaging, highly readable analysis of the latest research on how we learn and what we can do to improve the achievement of our pupils. Anyone involved in the care and education of children and young people would gain a huge amount from reading this book.

Dylan Wiliam, Emeritus Professor of Educational Assessment, University College London

I have not read another education book that brims with as much insight and stimulating thought as this one: every page serves up a new surprise or gentle provocation.

Andy Tharby, teacher, co-author of *Making Every Lesson Count* and author of *How to Explain Absolutely Anything to Absolutely Anyone*

Making Kids Cleverer is a truly magnificent manifesto. Everything David Didau says chimes deeply with what I know to be true and what I am trying to accomplish in our schools. It is an absolute joy to read, and an incredibly timely tour de force that can, and should, have a national impact. A must-read for everyone in education, from trainee teachers to inspectors and policy makers.

Lady Caroline Nash, Director, Future Academies

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