INTRODUCTION

Learning is at the very core of what teachers hope their students will spend most of their classroom time doing. Teachers can create the conditions that will maximise opportunities for learning to occur. As a teacher, it is critical for you to appreciate what learning is, how learning is understood and how it works so that you are best able to facilitate it. Knowing about learning is a key responsibility and challenge for all teachers.

From birth, all humans experience learning and develop intuitive ideas about how they can learn and how others learn. Increasingly, though, research is demonstrating that many intuitive ideas people develop about learning do not match with how learning seems to work in the brain and mind. Learning is a complex process. Learning can also be thought of as the outcome of a developmental process. It can be undoing what we think we know, as much as about acquiring and using new ideas. Research in the field of educational psychology and the **learning sciences**, in particular, show that learning is enormously complicated. Even the aspects of learning that apply to all students can be challenging to understand, let alone the individual differences that students bring to the class with them and the various trajectories they take as they develop their understanding of the world.

Learning sciences: an established field of research examining fundamental learning processes relevant to education and working with educators to apply the findings in educational settings.

WHAT IS LEARNING?

Learning: the process of an organism changing from one state (physical and/or mental) to another on the basis of experience and the outcomes of the change process.

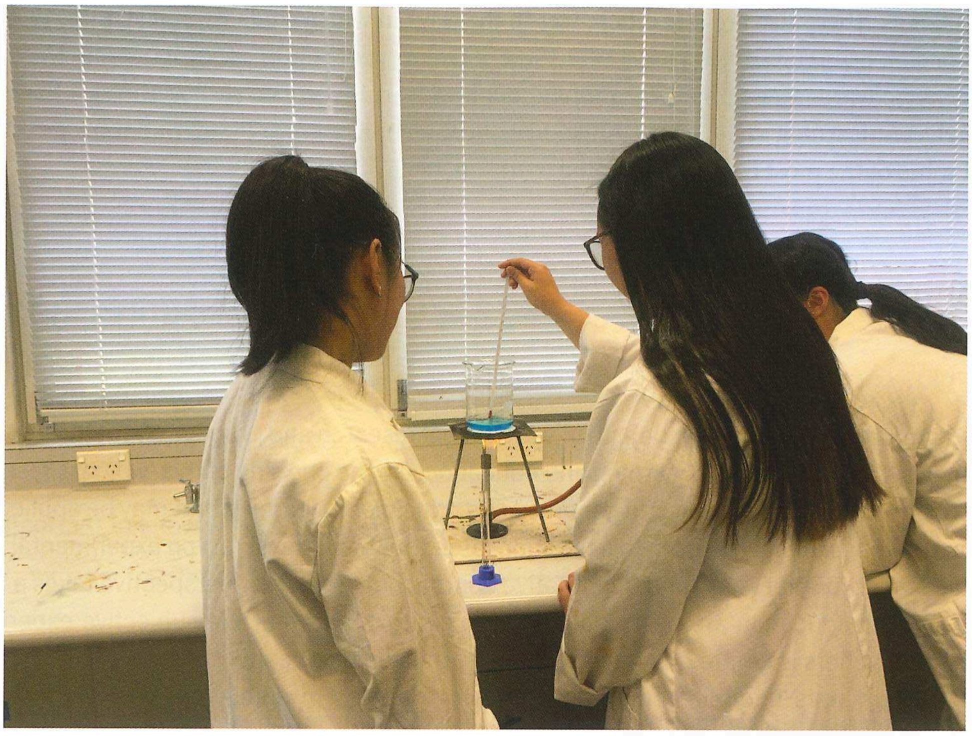
Human **learning** involves biological, cognitive and social aspects. Learning is both a process and the outcomes of that process. Definitions of learning vary according to the level at which we try to understand it. Learning looks very different to a neuroscientist than it does to a teacher in the classroom, for example, but at the core of this complexity, learning can be encapsulated by a broad definition.

Importantly, learning is not just about accumulating knowledge – there is much more to learning than just knowing. In humans, learning can be evident through changes in behaviour, but also through changes in ways of thinking and feeling. Learning can be a process of developing deeper understanding. The definition of learning needs to be broad to encapsulate all possible aspects of learning processes and outcomes in humans and other creatures.

Given how complex learning has proven to be, there is understandably some disagreement between researchers and theorists about how it works and how we can best understand it. At the core of these debates is some uncertainty about whether it is more effective to understand learning as a fundamental process that generalises across humans, or whether learning needs to be understood within context. John Dewey (1933), an influential American scholar with a background in philosophy and psychology, argued strongly for the latter. Edward Thorndike (1913), another influential psychologist active in the first half of the 1900s, took a different perspective, arguing that generalisable principles of learning are the key to effective instruction.

In recent years, the Dewey versus Thorndike debate has been exacerbated by two parallel trends. One is the emergence of the field of cognitive neuroscience. Over the past several decades, more has been uncovered about how the brain works. This has been largely due to the emergence of sophisticated brain imaging techniques such as electro-encephalography (EEG) and functional magnetic resonance imaging (fMRI). These new tools have allowed researchers to see the learning brain in action. As a result of these new techniques and associated findings, the subfield of **educational neuroscience** emerged. This was focused on how brain research could help to enhance education. Research conducted in cognitive neuroscience is aimed at determining general principles of learning and has added fuel to the ongoing debate about the appropriate level of analysis (brain, mind, student or classroom) required for

Educational neuroscience: an emerging field of research focused on applying research on the workings of the brain to learning and teaching in the classroom.



understanding learning. Does our growing understanding of the brain really help to improve learning in the classroom? That remains an open question.

A second trend contributing to ongoing uncertainty about the appropriate way of understanding learning for education is the emergence of powerful information and communication technologies (ICTs). While technologies provide possibilities for helping all students to learn, the design of these technologies often treats students as being all the same. For example, if you think about an educational video you have watched or some other online resource you have accessed, there is very little room in most of these technologies for you to learn in a way that best suits you. The video is presented in the same way to everyone who is learning from it, and there is no adjustment to the video based on the learning needs of the individual watching it. The emergence of more data-driven approaches to the design and implementation of such technologies has complicated this issue. Data are used as a means of personalising the learning experience for each student. One of the assumptions behind this approach is that online behaviour can be used as a way of understanding how students' learning progresses over time (Lodge et al., 2017). These data are crude, and do not provide a comprehensive picture of how students are going. For example, a student might be clicking on an educational site many times, but this could mean they are engaged, are becoming frustrated or that their mind is wandering. It is not possible to assess, on the basis of the behaviour alone, what the student is experiencing. Again, the basis for this data-driven approach to personalising learning is that there are generalisable patterns in behaviour that can inform the way the technology works. In sum, these emerging technologies often add to problems caused by assuming all students learn the same way.

The ongoing debates about the nature of learning (sometimes referred to as the 'paradigm wars' – see the 'Connections' box) have not helped to advance education. As with many either–or scenarios in life, it is important to understand the aspects of learning that apply to most students, but to also be mindful of, and cater for, student diversity by differentiating learning activities. As a teacher, it is vital that you are familiar with some of the fundamental theories of learning, while keeping in mind that there is no one definition of what learning is, where it occurs or how to best facilitate it. Learning can be seen to occur in the brain, it is evident throughout the animal kingdom, and there are aspects of learning that apply to all of us. There also are vast differences in the ways in which students can, and like to, learn. As a professional, it is important for you to be critical of claims people may make about how you can help your students to learn. Many popular notions about how learning works, such as the idea that students have a preferred learning style, for example, have been debunked (see Pashler et al., 2009). We have included some of the most common learning myths in Table 5.1.

CONNECTIONS

PARADIGM WARS

The paradigm wars are an ongoing debate in educational research and practice about the appropriate level of analysis for research into learning and education. On the one side of this 'war' are researchers and practitioners who are interested in generalisable principles of learning that may be applied across educational settings. Researchers in this tradition often (but not always) rely on experimental studies, large-scale standardised testing and quantitative approaches. The other perspective takes a position that learning and education are best understood in context, and that the subjective experience of students and teachers is central to understanding learning and education.

The paradigm wars underlie some other, ongoing debates in education, such as those about NAPLAN (National Assessment Program – Literacy and Numeracy), and arguments between those who support traditional approaches to education and those with progressive views. The paradigm wars and their symptoms have been deeply damaging to the enhancement of education across the world. However, the complexity of learning and teaching means that some disagreement about what learning is, and how to best create the conditions for it, is inevitable.

Table 5.1 Persistent myths in education, according to Kirschner and van Merriënboer (2013)

Myth	Description	What the research says
The digital native	This idea is that people born after 1990 or so are 'digital natives' who are completely familiar with and able to use technologies, as they have grown up with them and used them all life. People born earlier are less familiar with and have less capability due to not having grown up with these technologies.	The ability to use technology is largely not a factor of age but of socio-economic status and opportunity to learn to use technology well. There is also little transfer from one technology or service to another. For example, using social media a lot does not help develop skills in using spreadsheets or digital editing software.
Learning styles	The idea is that people have preferences for learning in certain ways. The most widespread of these ideas is that these preferences are modality-based – that is, people are visual, auditory or kinaesthetic learners. Instruction should therefore be designed to cater for these preferences in order to be most effective.	While it is true that people do have preferences for learning, these largely have little to no effect on the impact of educational experiences. In particular, modality preferences make no difference to the quality of learning in different channels. Individual differences in learning are more subtle and complicated than the learning styles theory suggests.
Knowledge-free learning	The access to knowledge and information on the Internet now means that people need to develop skills in other areas and no longer need to acquire knowledge.	The idea that people do not need to know things because they can so easily be found on the Internet is a seductive but incorrect one. Foundational knowledge in memory is as important as it has ever been. It is impossible to think critically about something if there is nothing in one's mind to think critically about.

PAUSE AND THINK

How do you learn best? Do you think there are aspects of your own learning that are constant, and that transfer from situation to situation? Or do you think that each situation in which you find yourself learning is unique and requires a completely different set of skills?

Suggested response in eBook

REVIEW QUESTIONS

1. What is learning?
2. What has been the major disagreement about learning among researchers and theorists over the past century?
3. Is it important to know whether your students are 'visual learners' or 'auditory learners'?

Guided responses in eBook

THEORIES OF LEARNING

There are almost more theories of learning than it is possible to count, and learning can be understood across many levels of time and space. At the most foundational level, learning can be seen to occur in very small parts of the brain over millisecond time periods. At the broader level, learning to become a teacher, a lawyer or a medical practitioner, for example, takes years and occurs within a complex social, political and economic environment. Some theories of learning focus on only one of the many levels in which learning occurs, while others attempt to explain learning in a more holistic way. The theories have also changed as new tools and new metaphors have become available over time. As you will see, there has been a shift away from using computers as an analogy for how the brain and mind work towards trying to understand learning in the brain and mind as a complex system.

Historical views of learning

There are two key lessons we can learn from the history of learning theories. The first is that our understanding of learning can change drastically over time. The second is that there are some fundamental aspects of learning and instruction that have withstood the test of time. Your own understanding of learning will change over the course of your career as a teacher. An appreciation of the breadth of learning theories will help you to think carefully about new ideas and approaches that become popular in education.

Early theories of learning

Theories of learning developed in many cultures across the globe. Many of the ideas about learning in the Western tradition of thought are attributed to the ancient Greek philosopher Socrates. There is discussion to this day about the **Socratic method**, which is an approach to dialogue that involves continued questioning and probing about elements of a person's views.

Socratic method: a form of instruction that relies on dialogue in the form of questioning to help students develop deeper understanding.

A renewed emphasis on learning occurred during the Enlightenment, in the late sixteenth to eighteenth century. It was at this time that some fundamental debates about the learning process began to emerge. For example, the philosopher John Locke argued that humans begin their lives as a blank slate (he referred to this as a 'tabula rasa') and that all human characteristics and behaviours can be traced to experience. Forms of this argument still exist today, but research on DNA and evolution have given us a more comprehensive understanding of how the mix of genes and environment (commonly referred to as nature versus nurture) contributes to learning and academic success. Humans are not born as blank slates, but nor are our genes our destiny. It was during the Enlightenment that these questions were initially debated, and for many centuries, people did not have any real sense of how we learnt, beyond these philosophical debates. It was not until the nineteenth and twentieth century that the story of learning became clearer, at least in Western societies (see the 'Connections' box for a non-Western viewpoint).

CONNECTIONS

NON-WESTERN THEORIES OF LEARNING

Not all students and not all cultures see learning in the individual-focused manner that Western theorists assume. There are rich traditions in other cultures that emphasise people learning together or through more collective cultural forms. Two examples are described below.

EASTERN THEORIES

Learning from Eastern perspectives tends to be seen as a much core collaborative and collective phenomenon than Western traditions, where learning is often focused on the individual learner and what is occurring in the minds of individuals. For many people in the world, learning is much more deeply embedded in social and cultural contexts. The notion of an individual learner can be at odds with these more collective ways of conceptualising learning. As a teacher, this is something to be mindful of if your students have non-Western cultural backgrounds.

INDIGENOUS PERSPECTIVES

Indigenous cultures throughout the world also have perspectives on learning that differ from those in a Western context. For Indigenous Australians, for example, there is a much greater emphasis on story and mythology as central mechanisms for learning. Again, this difference in perspective is important for you, as a teacher, to be mindful of.

Learning theories in the twentieth century

Beginning in the late nineteenth century, more sophisticated learning theories began to develop (see Table 5.2 for an overview of the major contemporary theories covered in this section). These new approaches tended to be more holistic and were often based on empirical evidence. In parallel, schooling became much more organised and increasingly compulsory in many parts of the world.

Table 5.2 Overview of major contemporary theories of learning

Theoretical paradigm	Major researchers/ theorists	Description of theory
Constructivism	John Dewey Maria Montessori Jean Piaget	This theory suggests that all knowledge is constructed and that learning occurs through the integration of new information and experiences with existing knowledge gained through prior experiences.
Social constructivism	Lev Vygotsky Jerome Bruner	Building on constructivism, this theory adds the social element to the construction of knowledge. Theorists in this tradition argue that knowledge is socially constructed, rather than being constructed in the mind of individuals.
Behaviourism	B.F. Skinner John Watson	Behaviourism is focused solely on behaviour as a means of understanding and impacting on learning – i.e. the brain and mind are seen as comprising a black box that cannot be measured or inferred.

Table 5.2 *(cont.)*

Theoretical paradigm	Major researchers/ theorists	Description of theory
Cognitivism	Noam Chomsky	The cognitive theory of learning sees the brain and mind as being like a computer. Researchers in this theoretical tradition are primarily interested in how the mind processes information.
Cognitive load theory	John Sweller	This theory relies on working memory limitations as a foundation. Sweller argues that instruction should be designed in order to limit unnecessary difficulties (see Table 5.1).
Multimedia learning theory (MLT)	Richard E. Mayer Roxana Moreno	This theory is based on cognitivism. MLT provides a means of understanding how different sensory channels combine to maximise learning.
Complex systems theory	Marlene Scardamalia Carl Bereiter	Understanding learning and education as a complex system is relatively new. This theory helps to incorporate all the diverse elements that contribute to student learning in education.

Constructivism

Constructivism: theory holding that learners construct knowledge on the basis of their prior experience and learning.

Perhaps the most dominant theory of learning over the past century was the theory of **constructivism**. This perspective assumes that learners construct knowledge on the basis of their prior experience and learning. New information and experiences are incorporated into the existing knowledge, or the existing knowledge is updated in some way. For example, we all have experience of how gravity works on Earth, and as students learn science, this experience is updated to new levels of understanding. The core of constructivism is that students actively construct their understanding, which has clear implications for teaching. When learning about gravity, students need to do the work to overcome their intuitive experience of gravity so they can construct a new conceptual understanding of the idea. More recently, constructivist approaches have underpinned growing interest and research in conceptual change. This research looks at how we conceptualise the world and our place in it, and how this is updated and changes with experience and new information. Constructivism therefore continues to be a very influential theory of how we learn.

Constructivism has also been built on and morphed into updated theoretical understandings. Jean Piaget, a Swiss psychologist, introduced ideas that have been incorporated into the cognitive theory of learning (Piaget, 1964). The dominance of constructivism can be seen in the ways in which it has been adapted and incorporated into other approaches. One of the most prominent extensions on constructivism is the theory of *social constructivism*, which added a social element to the initial theory. Social constructivists argue that knowledge is not simply constructed in the mind of individual students but is constructed through social interaction between students and between students and their teachers. This extension has served as an important foundation for more careful and systematic consideration of the important social dimensions in education.

Despite the dominance of constructivism, it has been criticised over the past decade (Tobias & Duffy, 2009). The empirical evidence emerging from some studies suggests that designing instruction based on this theory is not as effective as methods that take a more direct approach (Kirschner, Sweller & Clark, 2006). This is one of the main disagreements in the paradigm wars discussed earlier in this chapter. Is it better to provide opportunities for students to construct their own understanding or is it better to instruct them directly? The answer, as is the case with other dichotomous debates like this, is likely to be that a mixture of these approaches can be effective across different topics and classes, aligned with the way in which individual teachers go about their practice. Returning to the learning of gravity, for example, a classic approach is to carry out what is called a predict-observe-explain cycle. For example, students are asked to predict what happens when a bowling ball and a feather are dropped from the same height. Then they observe what happens and the counterintuitive observation (i.e. that they fall at the same rate) is followed up with an explanation of why this occurs. The predict-observe-explain cycle therefore leverages the best of discovery and direct instruction.

Behaviourism

Behaviourism: a school of thought that human and animal behaviour is best understood by treating the mind as a black box and examining behaviour only.

Another major theoretical basis for understanding learning came to prominence in the early 1900s and, as a school of thought, is still being used to understand basic learning processes today. **Behaviourism** treats the mind as a black box. The idea of a black box refers to the problem of knowing what is going on in someone else's mind. There is no way to know directly – we can only guess or infer, so behaviourists choose not to guess. In other words, this approach focuses on directly observable phenomena only. Most notably, John Watson and B.F. Skinner are associated with the behaviourist theory of learning. Perhaps the most renowned early contribution to behaviourist theory was made by physiologist Ivan Pavlov. His studies on what has become known as *classical conditioning* are known well beyond academia. The idea that a dog can be taught to salivate at the sound of a bell (technically, Pavlov initially used a metronome) is well known as 'Pavlov's dog'. This is one very early example of the notion of associative learning – that is, that learning occurs when two things are somehow paired together in time and space. *Operant conditioning* (for which Skinner, in particular, is more renowned – see Skinner, 1938) demonstrated the power of associative learning. When animals and humans are exposed to various reinforcers or punishers, these will lead to observable changes in behaviour. For example, rats learn to press a lever because doing so results in the rat getting a reward in the form of a food pellet.

The idea that the mind and brain are a black box and that behaviour should be the only phenomenon open for analysis in attempting to understand learning has largely been dismissed. Researchers studying behaviour as a means of understanding learning are increasingly incorporating new methods such as neuroimaging and mathematical modelling of underlying mechanisms to better understand the conditions underpinning the observed behaviours. Despite behaviourism falling out of favour, there is still a lot we can glean about students and their learning by observing what they do. There is also great power in the use of behaviourist approaches to helping students learn. For example, game-based learning largely relies on the mechanisms of operant conditioning in that students receive rewards of various kinds for completing activities.

Cognitivism: a theoretical perspective on the mind that focuses on information processing and sees the mind as being like a computer.

Behaviourism declined as a dominant theory of learning due to the emergence of cognitive theory. Instead of treating the mind and brain as a black box, **cognitivism** is focused on the mechanisms of the mind, such as the way it processes information. The analogy that best describes this theory is that of a computer. Cognition-based theory became dominant as a way of understanding human psychology in the 1970s and remained popular until the early 2000s. Research that attempts to understand the mechanisms of learning relies heavily on making inferences from behavioural and psychophysical indicators. The aim of studies founded on this theory is to come up with generalisable models for how the mind works. Research carried out in the cognitive tradition has had enormous impact in many fields, including business, economics, health and, of course, education. Despite this impact, its methods have been criticised for being too reductionist and unable to account for the diversity that is evident in classrooms. As with other theories, those based on cognition as a foundation are useful, but do not provide a holistic account of how students learn in all classrooms at all times.

Contemporary theories of learning

Since the late 1900s, the field of the learning sciences has been central to helping understand how learning works. The learning sciences include input from many core areas such as psychology, anthropology, sociology and educational research. A fundamental aim of the learning sciences is to work with educators to develop generalisable principles for how learning works and to translate these principles in a way that is useful in education. Rather than the prescriptive approach advocated by Thorndike (1913) and others, the complexity and specificity of each classroom environment is recognised.

In recent decades, new powerful tools have become available that enable seeing the brain learn in real time. For example, electro-encephalography (EEG) allows researchers to see changes in electrical activity on the outer surface of the brain as it occurs over time. Functional magnetic resonance imaging (fMRI) allows for seeing the blood flow to parts of the brain as people are engaged in learning tasks. Both of these new technologies have provided significant insight into what is occurring in the brain while people learn. Central to these findings are the importance of attention, memory and executive functions (i.e. higher-order thinking processes). Through this research, we now have a far greater understanding about how these fundamental processes occur in the brain.

Despite the fantastic leap forward in our understanding of the learning brain, EEG, fMRI and other neuroscientific studies are very difficult to interpret for educational researchers and teachers. Tasks used in neuroscience studies tend to be short to allow for many repetitions. These repetitions are needed to separate noisy background brain activity from the processing that is essential to the tasks that participants are given in these studies. It is very difficult to adapt a realistic lesson for use in neuroscience research. For example, a lesson that is designed to help students gain new insights (or have an 'a-ha!' moment), such as learning about how the Earth rotates around the sun, is difficult to replicate in a laboratory. Once a complex idea like the heliocentric model of the solar system is understood, it is not possible to repeat the realisation as would be required in a neuroscience study.

The field of *educational neuroscience* has emerged in an attempt to make sense of how our growing understanding of how the brain works can help teachers in the classroom. The emergence of this field has coincided with an international effort to apply neuroscience and experimental psychology to education.

Link: Science of Learning Research Centre

The utility of research on the brain for use in education remains uncertain. We can say with confidence that the brain is involved in learning, but understanding the biology of learning has been found to not have a significant impact on whether or not someone is a good teacher (Horvath et al., 2018). It remains to be seen whether our growing understanding of the brain will be useful for education in the future (Bruer, 1997). It is important for teachers to be sceptical of claims made about the neuroscience of learning and its application to education.

Some of the most useful research from the learning sciences has been carried out in *psychological science*. Based in the cognitive tradition, the focus of these studies is on information processing in the mind (as opposed to the brain). One analogy that is useful (but limited) here is that: neuroscience examines the hardware of learning; psychological science examines the operating system; and educational researchers are interested in how the software runs in the world. By looking at fundamental processes such as attention, memory and emotion, findings of many, replicable studies have exposed some of the main barriers to learning and shed light on how students learn most effectively. For example, research on memory has shown that our capacity to remember and use information in real time is very limited. The research on short-term or working memory has been translated for education through cognitive load theory (CLT) (Sweller, 1994). See Table 5.3 for the main features of this theory.

Table 5.3 Core aspects of cognitive load theory, as outlined by Sweller (1994)

Aspect of CLT	Description	Example
Intrinsic cognitive load	Intrinsic cognitive load is the effort inherent in a task that is essential for completing the task and for learning.	Performing numerical calculations – e.g. if you are asked to calculate 5 x 5, the calculation you make requires intrinsic cognitive load.
Extraneous cognitive load	Extraneous cognitive load is generated through the mechanism by which a task or instructional material is delivered. This kind of load is generally best avoided.	Presenting material on slides while talking at the same time introduces extraneous cognitive load, particularly if there is a lot of text on the slides.

Table 5.3 (*cont.*)

Aspect of CLT	Description	Example
Germane cognitive load	Germane cognitive load occurs as a result of incorporating new information and knowledge into existing knowledge and thinking. It is an important part of learning complex ideas, in particular.	Coming to understand the complexity of weather patterns requires looking beyond personal experiences with weather and therefore induces germane cognitive load.

Suggested response in eBook

PAUSE AND THINK

Think about the students you will be teaching when you complete your studies. How old will your students be? What content area will you be teaching? What kinds of activities do you imagine you will be asking your students to do? Can you think of ways to reduce extraneous cognitive load in those activities?

This evidence-informed theory elucidates working memory load that is essential or distracts from effective learning through efficient use of these limited memory resources. Working, or short-term, memory is the capacity you have for holding and working with information at any one time. As opposed to long-term memory, which is the virtually limitless store of knowledge you have over the lifespan, working memory is very limited. That is why you often need to rehearse a string of numbers if you are trying to remember and use them in real time. The more you give your working memory to do – that is, the more you increase the load – the more difficult it is for you to effectively process the information you are receiving and working with. Finding ways to lessen this load is useful for helping students to acquire and update their understanding. For example, making the parameters or process of an activity clear to students means they can focus their efforts on the thinking required to do the task rather than get bogged down trying to make sense of what they have been asked to do.

Research in the learning sciences is a coordinated attempt to overcome the criticisms levelled at research founded on cognitive theory. There is great promise in some of the findings for robust approaches to help students to learn effectively.

Multimedia learning theory

Neuroscience and experimental psychology have provided some new ideas about how learning works and have helped to debunk some ideas. However, these fields are not the only areas contributing new ideas to learning theory. The emergence of increasingly powerful and fast technologies has led to a substantial increase in the availability and use of educational technologies (we will return to this later in the chapter). This development has, in turn, led to new ways of understanding learning as it occurs in digital and blended (a mixture of classroom and online) environments.

The most dominant and comprehensive theory attempting to explain how students learn with technologies is multimedia learning theory (MLT; Mayer, 2014). This theory aligns strongly with the principles laid out in CLT. MLT is particularly useful and influential in the design and development of educational technologies because it is founded on an extensive body of empirical research. For example, MLT is useful in helping to design audio-visual material, such as interactive websites and educational games, as it provides guidance on an appropriate mix of images, text and audio elements within these environments. Another emerging trend is the increased use of technologies and networked devices in education, including substantial efforts in the emerging fields of artificial intelligence, learning at scale and learning analytics. Much of the work in these areas has been focused on technical aspects of systems and technologies for learning.

Where to next?

The paradigm wars are still an ongoing element in the quest to understand how students learn. Both sides of the argument make valid points. It is important to understand the basic fundamentals of learning, but learning as it occurs in a laboratory is not like learning that occurs in a complex classroom or in other social environments. At the same time, learning in a single, complex environment does not tell us much about learning from which we can generalise to help within other educational settings. New theories of learning are now attempting to incorporate all these elements into a more holistic and comprehensive view of learning.

Complex systems theory (see, for example, Jacobson & Wilensky, 2006) provides a way of integrating the different levels of understanding of learning. In Chapter 1, you learnt about the Systems Theory Framework of career decision making (Patton & McMahon, 2014). Here, the idea of complex systems is applied to learning. Complex systems theory is mostly based on observations of biological systems – for example, there are myriad local and global factors that influence the climate in any one place on Earth. This complex set of factors is why, even with all the computing power we have in the twenty-first century, it is not possible to predict with 100 per cent accuracy what the weather will be like tomorrow or exactly where a tropical cyclone will move over time. Nature is full of examples of complex biological, organic and environmental systems. Indeed, recent theories about how the brain works are more often than not built on the assumption that the brain itself is a complex system of billions of neurons connected and communicating with each other in enormously complicated ways.

Complex systems theory is relatively new and the implications of thinking about student learning in this way are still unclear. For teachers, complex systems are a way of understanding that there are no simple answers to what learning is and how it occurs in a classroom of diverse students. There are important lessons for teachers looking across all these theories, including an increasing need to understand and incorporate non-Western theories into our understanding of student learning processes. Many factors contribute to learning, from the neuron to the neighbourhood to the world. All of these factors must be taken into account and recognised as creating an enormously complex situation for teachers and students, and no single theory will capture all the important aspects of learning, particularly across cultures.

REVIEW QUESTIONS

Guided responses in eBook

1. Why is it important for teachers to be aware of the history of learning theories?
2. What is the nature–nurture debate? Why is it still important?
3. Why has cognitivism fallen out of favour as a foundation for learning theories?
4. Why is complex systems theory becoming popular as a way of understanding learning?

FACTORS IMPACTING ON LEARNING

Learning does not occur in a vacuum. There are many outside influences on how students learn in the classroom. These many factors are why complex systems theory is increasingly popular as a way of understanding learning. It is important to be aware of these factors, as they may limit how much each student can gain from a lesson.

Biological factors

It is obvious that students will go through dramatic physical changes during their years at school. This physical development occurs at different rates for all children. Increasingly, we are coming to understand the complicated relationship between the mind and the body. The field concerned with this relationship and its implications for learning is called 'embodied cognition'. The important aspect of this research for teachers is that there is an intricate interdependency between physical and mental development in children. While some elements of this relationship are generalisable across all students and are evident in the kinds of developmental stages outlined by Piaget and others, there are other elements of these processes that are far less obvious. Being mindful of the different biological developmental trajectories of students is critical for making sure they all reach their potential in the classroom.

Aligned with developmental trajectories, there are also developmental difficulties that some students experience. Among these are difficulties associated with autism spectrum disorder, dyslexia, dyscalculia and other disorders that manifest in learning difficulties.

CONNECTIONS

LEARNING DIFFICULTIES EXPERIENCED BY STUDENTS

Students can experience difficulties in learning for many reasons. Through neuroscience and psychology, we have developed a deeper understanding of some of the most problematic learning difficulties students might have. Some of the learning difficulties you are likely to come across as a teacher are:

- *Dyslexia*: dyslexia is a difficulty with language experienced by a small, but not insignificant, proportion of students. The symptoms of dyslexia vary substantially between people who experience these difficulties. Predominantly, people with dyslexia have difficulty with reading and/or spelling, but other facets of language comprehension and production can be affected.
- *Dyscalculia*: dyscalculia is the mathematical counterpart to dyslexia. As with dyslexia, dyscalculia can similarly differ markedly between individuals. Predominantly, sufferers have difficulties in comprehending and manipulating numbers and/or in performing calculations.

- *Autism spectrum disorder (ASD)*: it has been reported that a growing number of people are being diagnosed with ASD, which includes Asperger's syndrome. ASD is still not completely understood, but manifests most obviously as severe social problems or withdrawal. ASD is a complex set of disorders. It can be difficult to diagnose in many cases and each individual with one of these disorders will have different capabilities and may struggle to learn in unpredictable ways. Some people with ASD excel at learning in some areas, while others do not.
- *Attention deficit/hyperactivity disorder (ADHD)*: this disorder has received a lot of coverage over the past two decades. Some students do genuinely struggle to maintain focus and are hyperactive. ADHD is a legitimate psychological disorder and it is important to be mindful that some students may have great difficulty in paying attention and sitting still in the classroom.

As a teacher, it is not your job to diagnose students. It is important to seek support if you feel that any of your students are struggling and you suspect there might be a specific learning difficulty involved. These cases need to be handled with utmost care. A diagnosis can be devastating to children and parents. Make sure you ask for advice from colleagues and get support to best help students if they are really struggling with their learning.

Cognitive development

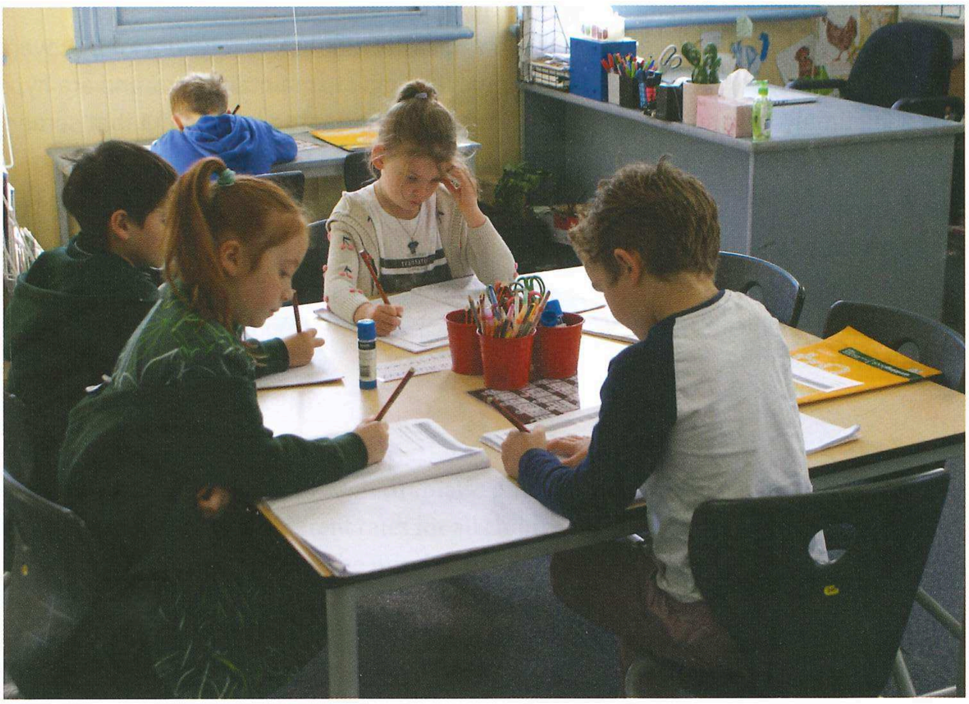
There has been much emphasis on the cognitive development of children as they grow older. This is perhaps not surprising given that the development of cognitive skills is quite obvious to parents and teachers. There are dramatic shifts in the ways in which children think about and work with ideas and objects in the world. These changes can sometimes seem to occur overnight or over short time spans.

There have been many stage-based theories of cognitive development put forth over the past century. Perhaps the most well-known of these frameworks is Piaget's stages, as outlined in Table 5.4.

Table 5.4 Piaget's (1964) developmental stages

Piagetian stage and ages	Description of stage	Example
Sensorimotor 0–2 years	The first stage involves children developing a basic understanding of the world primarily through their senses. An important aspect of this stage is developing a sense that objects have permanence and can be identified and named.	Movement and the sensory experience of the world dominate this stage. For example, children at this age like to manipulate objects and taste them.
Preoperational 2–7 years	During this stage, children develop a sense of symbols and ideas, and greatly enhance their capacity for language, but remain egocentric and have difficulty accepting the viewpoint of others.	Children will develop their vocabulary rapidly, but also tend to be selfish and unable to see someone else's viewpoint.
Concrete operational 7–11 years	Children develop their capacity to think logically during this stage and become better at seeing others' viewpoints. They generally do not yet have the capacity to think in abstract terms.	Children will develop a sense of conservation at this stage; they will, for example, understand that a tall skinny cup and a short wide cup can hold the same volume.
Formal operational 12 years and up	Thinking at this stage begins to resemble that of adults. This stage is characterised by an ability to think abstractly and hypothetically, and a fully developed sense of self in relation to others and how others think and feel.	Children at this age will, for example, be able to consider moral or philosophical issues.

Stage-based cognitive developmental theory has intuitive appeal because it is often relatively straightforward to see children transition from one stage to the next. For example, it is relatively easy to spot when infants first develop a sense of object permanence, as it is all of a sudden fun for them to play 'peek-a-boo'. Prior to developing object permanence, peek-a-boo does not register.



Despite the intuitive appeal of stage theories, it is not feasible to use these as anything more than broad heuristic categories. The reality is that children will develop cognitive capacities at different rates. There can be too much of a tendency to pigeonhole children who do not fit neatly within the categories or developmental stages at particular ages, as either gifted at one end of the learning spectrum or in need of remedial help at the other. As a broad outline of how children develop, these stage models are useful, but they are not meant to be, nor should they be, prescriptive.

Emotions and learning

Over the past quarter of a century, there has been a strong focus on the pivotal role that emotions play in the learning process. In some cases, the impact of emotions on learning is obvious. Mathematics anxiety is one example of this. Anxiety about learning mathematics or statistics is not helpful for facilitating learning. As a teacher, it is important for you to be aware of students' emotional responses to different topics or learning situations, as it can be greatly beneficial in these situations to help students find ways to manage these emotions so that they do not interfere with learning.

Suggested response in eBook

PAUSE AND THINK

Do you need to be a counsellor or a psychologist to be a good teacher?

In recent years, there has been a particular interest in what have become labelled the '**epistemic emotions**'. These emotions are core to the learning process, as they are emotional responses to the process of knowing and understanding. The research on these emotions is still emerging. However, it is becoming clear that they are key to effective learning experiences for students. For example, the development of a deep, personal interest in a topic area will have implications for how engaged and motivated a student will be to learn about the topic. Although this relationship may seem obvious, it is becoming apparent that the development of interest is extremely powerful as a foundation for engaging students in their education.

Epistemic emotions: emotions that are related to knowledge, knowing and/or understanding such as interest, confusion or curiosity.

Social and cultural factors

Social and cultural factors play an important role in determining how students learn. Much of the emphasis in this chapter has been on individual factors and the individual student as the central unit of learning. That focus is not intended to downplay the importance of social factors for student learning. The environments that students have grown up in and are exposed to on a day-to-day basis have a critical effect on student learning. These experiences align with sociocultural theories, such as social constructivism. The impact of social and cultural factors on learning is profound, and cannot be overstated.

Social factors, which include socio-economic status, will affect the ways in which the makeup of the class impacts on students. There will be dynamics in every class that will deeply affect all the students in the room. Similarly, the cultural backgrounds of all students greatly impact on what they bring to the classroom. For example, if a student is from a background that does not encourage students to speak up for themselves, it can be very difficult for that student to engage in activities where they might be asked to speak up in front of the class. As a teacher, it is important for you to be mindful of the social environment in your classroom and the cultural experiences that shape how students will approach what they do.

REVIEW QUESTIONS ▶ ▶ ▶ ▶ ▶

1. How does biology affect students?
2. How do emotions influence learning?
3. Why should stage-based developmental frameworks be treated with caution?
4. Why is it important to consider social factors in learning?

Guided responses in eBook

INDIVIDUAL LEARNING NEEDS AND PERSONALISATION

The emergence of educational neuroscience and the ongoing influence of the learning sciences might lead to an impression that generalisable aspects of learning are the main consideration; however, this is not the case. One thing that will be immediately evident to you in the classroom is that there is great diversity among any group of students (refer to Chapter 4 for an in-depth discussion of diversity). You also will be working with students who face additional challenges in their learning through social or economic disadvantages, disability, or other personal factors that may affect their capacity to learn in a mainstream classroom.

What can teachers do to ensure that the lessons they design and deliver will be most effective for helping all students in the class to learn?

Balancing the needs of all students

As we have already shown, there are important differences between students that need to be accounted for when designing for learning. Thinking about what will work for most students, and what will need to be done to help students for whom a certain approach might not work, is a constant difficulty in education. Understanding the aspects of the learning process that can be generalised to all students is a start. Aligned with this knowledge, it is also critical to understand the needs of individual students.

Universal Design for Learning (UDL): an approach to designing instruction based on evidence of what will work for the maximum number of students most of the time, taking into account the diversity of students.

One way in which learning can be designed to create the best conditions for learning for the greatest number of students is through an approach called **Universal Design for Learning (UDL)** (see also Chapter 11 for further discussion of UDL). As a way of thinking, design is distinct from a scientific or human-centred way of understanding the world. Design thinking focuses on what the world could be rather than on what it is (as per science) or what the human experience of the world is (as per the humanities). UDL involves creating instructional conditions that are most likely to help most students most of the time. The benefit of engaging in these practices is that they allow you to set the conditions that will maximise the chances that students will learn, and they provide some flexibility for you to provide additional support to students who need it. Using UDL is not a panacea, though. As we have discussed, you will have students with different backgrounds, different strengths and weaknesses, and developing at different rates.

Catering for all students

Catering for the needs of all students is difficult. Understanding how students learn is an important part of helping to ensure all students are developing in their learning. UDL is an important way to help students learn, particularly when it is balanced with an emphasis on the diversity of students in the classroom. As a teacher, one of the most effective ways to help your students learn is to get to know them as much as possible. The principles you can derive from the history of research and theory on learning will help you to become proficient at the technical aspects of teaching, including design. Knowing your students and understanding their individual circumstances and needs will transform you from a good designer for learning to a great teacher who can have real impact on your students' lives.

Given the current state of our understanding of how people learn, and the important differences students bring to the classroom, there are challenges in ensuring all students are able to learn in the ways we are coming to understand are the most effective. Implementing UDL means that curriculum and lesson planning will work for most students most of the time. However, the diversity of students means that teachers also need to be mindful that even the best planned lessons will not work for every student all the time. We have already discussed the biological and social differences students bring to the classroom, but there are also other differences, which can be addressed by adaptive and personalised approaches to learning. We will first look at some of these key differences.

Prior knowledge and learning

Despite what John Locke suggested in the 1700s, students do not enter any classroom as blank slates. Even students who are in their early childhood have had a range of experiences and developed an understanding of how the world works. Teachers can mistakenly assume that students are starting from scratch when they begin learning a new topic. In some cases, such as when learning something like coding, that may be partly true. In many other areas, such as literacy and science, students often have vast experience in language and in exploring the world. Students will try to build on their prior knowledge and experience when learning, and it is helpful for teachers to create conditions that will allow them to do so. This might mean helping them to undo what they think they know if, for example, they have misconceptions about something.

PAUSE AND THINK

Think about a common misconception in your curriculum area. How might you help students to overcome this misconception?

Suggested response in eBook

The experiences that students have of the world will form an important foundation for how they try to understand what you will be helping them to learn. It is important to find ways to bring this knowledge into the lesson wherever possible. This can be as easy as starting out by asking students what they know about the topic. For example, a good way of beginning a lesson on the human sensory systems is to ask students how many senses they think we have. Later primary and high school students (as well as many adults) have likely been exposed to the idea that we have five senses (sight, hearing, smell, taste, touch). Current thinking in sensation and perception is that we have at least 21 senses. By asking the question, prior knowledge about the senses is activated through this simple approach. This, and many other practices and lesson designs, will similarly help students to tap into their prior knowledge at the beginning of, or during, a lesson. Given the importance of this prior knowledge to the way in which students will try to make sense of what they are learning, using opportunities to activate prior knowledge is a useful idea.

Self-regulated learning

One area of particular interest in research and practice in recent times is that of **self-regulated learning (SRL)**. SRL is a process where students monitor their own progress and make decisions about how they will progress as they learn. SRL has become increasingly important as students at all levels of education engage in learning in online environments and other situations where a teacher is not able to intervene in real time. It has, however, always been the case that teachers have largely been unable to provide individual instruction to each student at all times. The capacity students have to make judgements about how they are progressing and make good decisions about where to go next are critical skills for them to develop so that they can continue to learn throughout their lives.

Self-regulated learning (SRL): where students monitor their own progress and decide how they will progress as they learn.

As with many aspects of learning, SRL is complicated. There are numerous theoretical models for how students regulate their own learning (for a review, see Panadero, 2017). Given its importance, SRL has become one of the most researched topics in educational psychology in recent years. Figure 5.1 highlights some of the most important aspects of SRL. In particular, note that the process of making judgements about how they are going (monitoring) and the process of taking action (decision making) on the basis of thinking about that progress (metacognition) are core aspects of SRL in this model. Monitoring and decision making are areas where you can help students to improve their own capacity to learn.

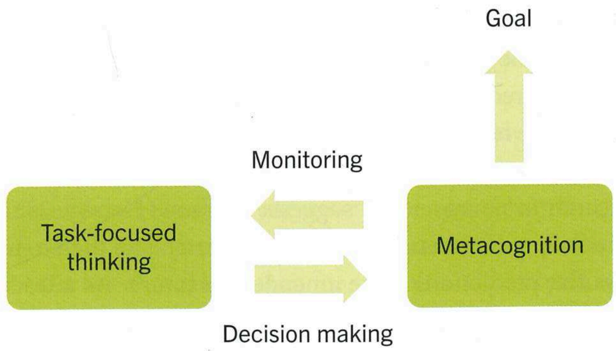


Figure 5.1 Simplified model of self-regulated learning (based on Lodge, Kennedy & Hattie, 2018)

As a teacher, it will be important for you to look for opportunities to help students to develop their capacity for SRL, although that is not always easy to do. The reasons why students engage in learning are often not obvious and students will have vastly different levels of capability in SRL. One key moment where there are opportunities to help students develop SRL is when they become confused or stuck while learning. Confused students are relatively easy for teachers to spot as the 'confused face' is something most teachers become familiar with early in their careers. Confusion and reaching an impasse both serve as cues that a student might not be using an effective strategy or is struggling to incorporate new ideas into what they have previously learnt or experienced. Confusion has long been seen as something to avoid in the learning process, but it can be important for students to experience confusion because of this cuing function (D'Mello et al., 2014). Often, confusion or an impasse is an opportunity to help students focus on trying new strategies, and the more students are able to identify that they are stuck and swap to a new strategy, the better they will become at regulating their own learning.

Suggested response in eBook

PAUSE AND THINK

Think about your own learning processes. What do you think are the effective things you do to learn? What are some things you think are not helping?

Motivation, goal setting and mastery

An important difference among students in your classroom will be in their motivation to learn. Motivation can differ widely between students, and within individual students at different times and for different topics. For example, a student who has had trouble and experiences anxiety about mathematics may show little motivation to engage in a maths lesson, but be highly motivated to learn about history. Motivation has been a topic of research in education and psychology for many decades. Individual interest in the topic, a student's sense of their capacity to learn and their self-regulatory processes are all related to how motivated they are to learn.

Teachers need to know about the two broad kinds of motivation. *Extrinsic motivation* is when people are motivated to act based on some form of external reward – for example, game-based learning, where people get points or win prizes, creates extrinsic motivation to participate in the game. *Intrinsic motivation*, on the other hand, is when people engage in behaviours and activities for the reward of the activity itself. One goal for teachers is to try to instil in students a love of learning, which encapsulates the intrinsic motivation to learn.

Feedback

One of the features of learning that is most important for helping students develop is feedback. From basic neuroscience studies, right through to applied classroom research, the power of feedback is apparent. Feedback provides students with important information about how they are progressing, where to go next and ways in which they can develop their own capacity to judge their progress and make decisions. We have already covered the importance of self-regulated learning for students. Feedback is central to helping students figure out how they are progressing, which, in turn, helps them develop their capacity to make better decisions about where to go next.

The foundational research in neuroscience suggests to some (Hohwy, 2013) that the brain itself is fundamentally wired to make predictions about the world, to act, and then to receive feedback on those predictions, which allows the predictions to be amended in future. As a teacher, it is imperative that you consider carefully the kind of feedback you provide students. Your input will not only help students improve on a task but, if done well, can help them fundamentally make better progress on similar tasks in the future. The best forms of feedback help students beyond the immediate activity or task they are undertaking, and the neuroscience behind the fundamental processes helps us to understand why.

Personalising learning

Personalising learning broadly refers to the process of designing lessons or activities that meet the learning needs of individual students. This can be achieved in many ways. In recent years, there has been discussion about achieving personalised learning experiences by rethinking how students progress through education. One example of this has been the discussion about removing the alignment between year levels and age groups – see, for example, the review of the Australian Curriculum (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2020). The intent here is to allow students to progress on a trajectory that suits them, rather than one that aligns with their biological age. Given the issues we have already covered about stage-based approaches to understanding childhood development, there is a sound basis for this argument. There is certainly merit in personalising the educational journey for each student based on a development trajectory that is theirs alone. However, there is also a possible downside, particularly for students who are deemed not to be progressing at a standard that aligns with other students of a similar age. Also, it can be difficult to implement this kind of personalisation in practice, as there are not limitless resources in education to provide a unique learning experience for every student. There are great prospects for personalisation when it is done well, so this is an area that will continue to receive attention.

REVIEW QUESTIONS

1. In what ways is Universal Design for Learning (UDL) useful?
2. Why is prior knowledge an important element to learning?
3. What role does motivation play in engaging students?
4. Why is self-regulated learning an important topic in educational research?

Guided responses in eBook

HOW DO WE KNOW WHEN LEARNING HAS OCCURRED?

One further question that we need to address is how to tell when learning has actually occurred. The most obvious answer is that teachers see evidence of learning through assessment or other kinds of captured performance. The issue with assuming that assessment will provide sufficient evidence of learning is that assessment tasks provide a snapshot of performance and do not necessarily capture the developmental trajectory of students. Given our discussion about the different theories of learning and the paradigm wars, it is probably not surprising that there is also disagreement about what kind of evidence is sufficient to provide certainty that learning has occurred. While much of the emphasis of this chapter has been on the process of learning, the outcome of this process is also part of the definition we are using for learning and therefore must also be considered.

A trend over the early part of the twenty-first century has been to rely on standardised testing regimes for determining whether or not learning is occurring. Internationally, examples of these tests include PISA (Programme for International Student Assessment; see also Chapter 3) and TIMSS (Trends in International Mathematics and Science Study), both large-scale tests conducted across many countries. In Australia, the NAPLAN test is a core mechanism for schools and policymakers to obtain evidence of learning. However, standardised testing has been heavily critiqued and is perhaps not the most effective means of determining whether learning has occurred in classrooms. The problem remains that it is difficult to develop a clear sense of how much learning has occurred using a broad measure such as standardised tests of this kind.

Assessment as learning

One idea that has emerged as a way of reconsidering the role of testing and assessment in education, and which provides a clue as to the alternatives for determining how students are progressing, is the notion of assessment as learning. *Assessment as learning* is the idea that learning activities and assessment tasks are integrated so that students are working towards the completion of assessment while they learn (Wiliam, 2011). Assessment is covered in detail in Chapter 9, but the important point here is that learning activities and assessment tasks have often been considered in isolation. For example, students might complete workbooks or other activities in class and then be examined in a completely different setting using a formal examination. Assessment as learning in this example would be where the process and the outcome of the completion of the workbook itself become what are assessed, rather than the students being assessed through an examination later on.

There are many advantages to the integration of assessment and learning. One is that the integration gives teachers a better sense of how students are progressing. Examinations provide only a snapshot of how students are developing, with the focus being much more on performance than development. The second major advantage is that there is less stress placed on students to perform under exam conditions. Many students find exams to be anxiety-provoking. Being assessed through their learning provides opportunities for all students to demonstrate their progress over time, rather than through a high-stakes snapshot. Finding opportunities to assess students while they learn provides advantages for teachers as well. Learning is, after all, a developmental process, not just one performance at a single point in time under conditions that many students find difficult.

REVIEW QUESTIONS ▶ ▶ ▶ ▶ ▶

1. How do we know that learning has occurred?
2. Why is assessment as learning important?

Guided responses in eBook

LEARNING IN THE TWENTY-FIRST CENTURY

The final major area of discussion in this chapter is about learning and technologies. ICTs are so deeply integrated into life and learning that it is important to consider the role they play in learning in the twenty-first century. There is substantial controversy about the use of technology for learning and the various impacts technology might have on the learning process. ICTs can be a great help or a great hindrance for learning, and it is important for teachers to be aware of the fundamental relationship between learning and technologies to be in a position to make good decisions about using ICTs in the classroom.

Technology and learning

ICTs of various kinds can be useful for enhancing student learning. However, there are also substantial risks that ICTs can detract from or distract students from learning effectively. Overall, the evidence – for example, from Hattie's (2009) analysis of many studies on the use of technology in education – suggests that the negative aspects of technology use in education have outweighed the positive. However, this finding may well be due to inadequate pedagogies for the effective use of new tools and systems for helping students learn, rather than being inherent in the technologies themselves.

One major difficulty in determining whether ICTs are good or bad for learning and how best to use them is that the research lags well behind the development of new technologies. For example, the introduction and rapid uptake of smart devices and tablet computers happened far more rapidly than did the research examining these tools for effective learning. The lag means there is little guidance on how to get the best out of new technologies until sometime after they become available.

The affordances of technologies

Educational technologies provide enormous opportunities for enhancing student learning. The introduction of powerful personal computers, mobile devices and the Internet have already led to vast changes in how people source information and enhanced the ease of finding information on just about any topic. Whether this means these technologies are fundamentally changing the learning process remains to be seen. What is clear is that there has never been a time where it was easier to find information on almost any topic imaginable. This availability of information undoubtedly creates limitless possibilities for educational experiences beyond what were available only a decade ago. In combination with enhancements in multimedia, editing and sharing of content, there are great possibilities for the creation and sharing of educational material. Video sharing sites are already proving to be powerful tools for learning, with many people routinely accessing these sites to learn everything from cooking to quantum physics.

The pitfalls of technologies

As discussed, ICTs provide great opportunities for enhancing student learning. However, our understanding of the implications of using these technologies is far outpaced by the development and introduction of them. Rigorous research on what each new educational technology means in the classroom takes years to carry out properly. This means that the hype around some technologies can remain unchecked for some time. There are many examples of ICTs that were introduced with great fanfare and claims about them revolutionising learning in the classroom. These claims were often shown to have been exaggerated in the long run – for example, the relatively recent introduction of interactive whiteboards. These tools are useful, but they have not revolutionised education in the ways in which they were initially promoted.

As a teacher, it is important for you to maintain a healthy level of scepticism about the claims made about new educational technologies. There is much we are still learning about how students learn. When a new technology is introduced as groundbreaking and likely to lead to a revolution in education, some caution is warranted. Increasingly, there are also concerns being raised about the ethical use of educational technologies. For example, the collection of data about students and their activities as they learn is becoming commonplace in many online learning environments. It is not always made clear to students, teachers or parents that these data are being collected. It also is often not made clear what these data will be used for. There are, therefore, serious ethical concerns about some new, online technologies becoming available – for example, technologies that are used to track student behaviour, sometimes without their knowledge. There are also concerns about learning driven by algorithms that have biases built into them against some groups based on demographic or socio-economic characteristics.

REVIEW QUESTION ▶ ▶ ▶ ▶ ▶

Why should teachers be wary about new technologies in the classroom?

Guided response in eBook