Taber, K. S. (2023). Educational Psychology. In B. Akpan, B. Çavaş, & T. Kennedy (Eds.), ***Contemporary Issues in Science and Technology Education*** (pp. 193-207). Springer/ICASE.

Chapter 14

Educational psychology

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Abstract

This chapter provides a brief survey of key areas of work in educational psychology that are relevant to science and technology education. The chapter offers an introduction, accessible to general professional readers such as teachers, which seeks to: highlight the relevance and value of educational psychology for those working in education; indicate the breadth of the field and some of the key concepts and theoretical areas; introduce key areas of research into teaching informed by psychological perspectives; and encourage readers to consider exploring some of these topics in more depth. The diverse nature of perspectives and methodologies adopted in psychology, and the challenge of studying mental events, are highlighted. The preponderance of informal references to mental phenomena in everyday discourse (the 'mental register') is acknowledged as tending to make some psychological constructs seem more directly accessible and widely understood than is actually the case. Among the topics considered are 'theory of mind', perception, memory, cognitive development, scaffolding learning, metacognition, intelligence, giftedness, motivation and individual differences.

Keywords: Cognitive development, confirmation bias, Gestalts, giftedness, individual differences, intelligence, meaningful learning, memory, metacognition, motivation, multi-modal teaching, neurodiversity, perception, self-efficacy, scaffolding, theory of mind, working memory

Psychology applied to education

Psychology is recognised to be a diverse discipline, with a broad range of theoretical perspectives and methodologies. *Educational* psychology therefore encompasses *those aspects of psychology applied to examine, enquire into, explain or inform educational phenomena* – where education is centrally about teaching, learning and related concepts – curriculum, schooling, and so forth. This comprises a vast body of work, and this chapter can only offer a very brief taster to introduce key areas of work in educational psychology (see Figure 1). A good many of the research studies published in science and technology education draw upon educational psychology for their theoretical perspectives, so some familiarity with this field is important for those seeking to make science and technology education more 'research-informed'.

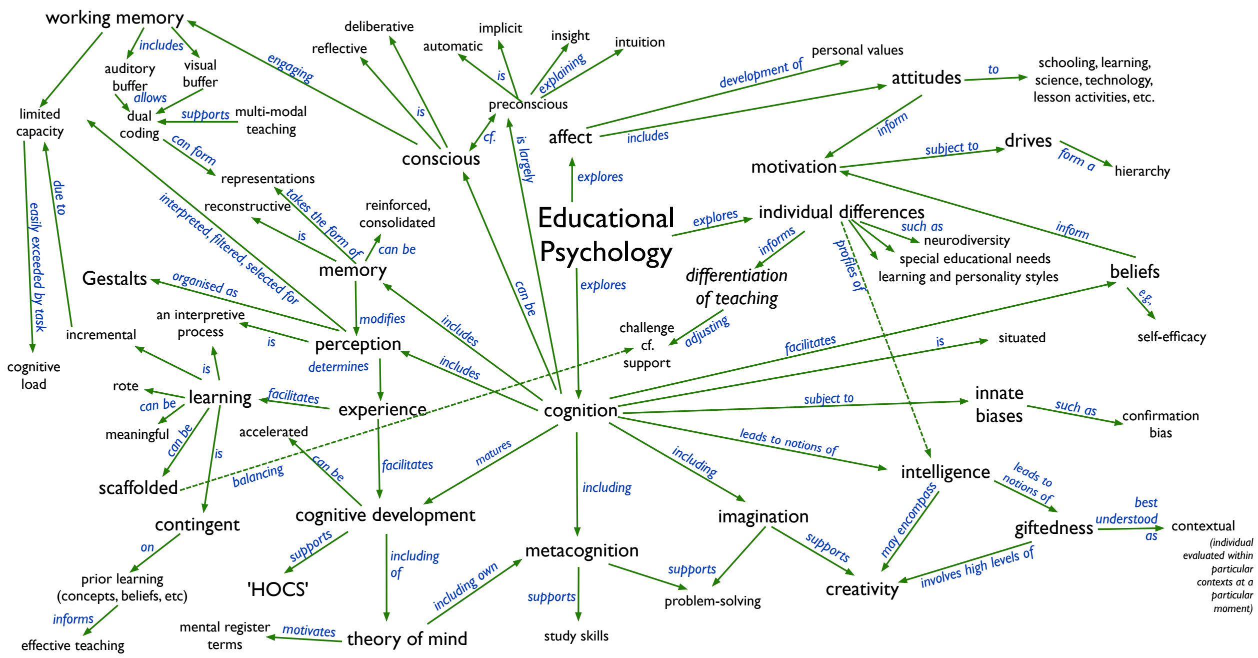

Figure 1. Some of the key ideas from educational psychology relevant to teaching science and technology.

The chapter format only allows a very brief survey of an entire field of research, intended to be accessible to the general professional reader (such as teachers and others working in education). It has therefore not been possible to cite many original sources: however, the suggestions for further reading provide useful starting points for readers who wish to explore topics further. The chapter therefore aims to (i) highlight the relevance and value of educational psychology for those working in education, such as teachers; (ii) give some indication of the breadth of the field, and some of the key concepts and theoretical areas; (iii) offer a 'primer' for those reading research studies into teaching informed by psychological perspectives; and (iv) encourage readers to consider exploring some of these topics in more detail.

What is psychology?

Psychology is the study of the mind. The mind is unobservable, and is indeed an abstract notion that helps us understand people's behaviour. Traditionally, psychology made a distinction between cognition (thinking), affect (feelings), and conation (inclination towards behaviour), although such a model may sometimes divide what may be better understood holistically.

Psychology is a broad discipline that has encompassed a range of quite different traditions. For example, most people know something about the psychoanalytic notions of theorists such as Sigmund Freud, Carl Jung and others. Famously, Freud would seek to interpret his clients' dreams in terms of their unconscious fears and desires. The psychoanalytic tradition is still active today, even if it is not commonly used in educational research. But much educational psychology does use interpretive methods to make sense of data (for example, from detailed interviews). Yet, it is also the case that other psychological research follows 'paradigms' (widely used outline research designs) adopting experimental methods much more akin to the kinds of investigations familiar from the school physics laboratory – controlling variables, compiling tables of quantitative results, and using statistical methods to reach conclusions.

One influential school of psychology, behaviourism, was informed by a perspective that sought to exclude unobservable entities from psychological explanations. That was in contrast to a tradition that admitted introspection (reflecting on one's own mental experience) as a useful tool. Although behaviourism is no longer a leading approach, the relative value of what can be objectively measured as opposed to subjective reports of personal experience remains a key issue.

As an extreme example, positron emission tomography (PET) scans, an objective technique, may be used to image a person's brain as they carry out some kind of cognitive task, but cannot be *directly* linked to mental experience, whereas a talk-aloud protocol can allow a study participant to describe their conscious thinking processes – but only offers a subjective account subject to biases and selective reporting, and requiring the analyst to interpret the participant's intended meanings.

Science and technology teachers may tend to be more convinced by research methods that *seem* more objective. Quantifiable entities may appear more 'real' than those relying on the analysts' interpretations, yet many constructs 'measured' in educational psychology (e.g. measuring *attitude to science*, measuring *self-efficacy*, measuring *science capital*) depend on Likert-type scales (e.g. 'please rate your agreement on a 6 point scale where 1 is strong disagreement and 6 is strong agreement') made up of sets of statements that have been found to be statistically associated among samples of respondents, and where individuals are asked to subjectively score at one moment in time.

Applying experimental methods to investigate teaching and learning is very challenging (Taber, 2019). For example, when working with human participants, there are serious complications that can confound experimental results (e.g., it has been widely demonstrated that a participant's *expectations* about what an experimental treatment might achieve – *which may be inadvertently communicated by researchers* – can strongly influence outcomes). Often educational research is undertaken with non-random samples from populations where it is simply assumed that '11-12-year-old schoolchildren' or 'teenagers with a diagnosis of autism' can be considered as if natural kinds, where 'specimens' are interchangeable when using statistical methods to reach conclusions. However, research actually shows that study findings may not unproblematically transfer between very different educational contexts.

The mental register and theory of mind

Psychologists have studied human development, and found patterns in areas such as developing sophistication of thinking and committing to a coherent set of personal values. Generally, human beings naturally develop what is known as 'theory of mind' (TOM): from quite an early age, we learn to automatically consider what others around us will think about what we do and speak. This means that we are all inherently *implicit* psychologists and it is very common for everyday discourse to include references to mental entities and events.

Whilst our mental experiences relate to consciousness, research suggests that we are only aware of a fraction of our cognitive processing – most is 'preconscious'. That so much of our 'thinking' is tacit becomes clear when we consider intuition (feeling that we know something, without having any idea of how we came to know) or when we have a sudden insight regarding some problem or issue (Brock, 2015).

There is a 'mental register' (cf. Box 1) of terms that we commonly use in relation to mental phenomena – remembering, learning, intelligence, understanding, knowing, thinking, and so forth – but when these terms are used in everyday discourse, they have somewhat vague meanings (Taber, 2013). In professional (e.g., educational) discourse, terms that might be considered to have a technical meaning need to be more clearly (i.e., operationally) defined, and educational psychology research often provides such clarity.

belief, clever, cognition, comprehension, concentrating, contemplation, creativity, cunning, day-dreaming, distraction, evaluating, focusing, forgetting, gifted, idea, imagining/imagination, ingenuity, intelligence, insight, intuition, knowing/knowledge, learning, memory, mental imagery, mind's eye, misconception, metacognition, perception, problem-solving, rational, reasoning, reflection, remembering, reverie, self-knowledge, thinking/thought, understanding, wisdom…

Box 1. The mental register: a selection of words relating to mental experience (Taber, 2013). Some of these words (a) are largely restricted to use in everyday discourse; but some (b) are also commonly part of the professional discourse of those working in education; and some (c) are used as technical terms in academic psychology and educational research. There is a potential for confusion where terms that may have *a well-defined technical meaning in research* are also *used in more fluid and diffuse ways within professional educational discourse*.

Perception

We might understand perception as the means by which we acquire data about the outside world – we see, hear, touch, and so forth. In education, perception provides experiences from which a person can learn. The student looks at the textbook or board or screen, hears the teacher, feels how the test tube has warmed-up, smells the vapour above the ammonium hydroxide solution, and so forth. Understanding how our sensory organs function is part of *physiology*. However, *psychology* has explored perception within a systems perspective – not how neural signals are generated (for example, in the retina) and transmitted, but how those signals are *interpreted* within the mind of the individual.

Making sense of perceptual data depends on innate and learned biases. Confirmation bias leads to more readily noticing evidence supporting rather than challenging beliefs – so teachers have to remember to draw attention to, and explicitly explain, evidence intended to challenge learners' ideas. Chicks will peck at certain simple abstract shapes that look (to us) nothing like parent birds, because the chicks are primed to respond to simple cues when being fed: similarly, humans seem to have an innate predisposition for making sense of minimal data to see faces:

(-: 😁.

Most people are familiar with optical illusions, which show that perception is not just a matter of our senses telling us what is in the world. So, for example, there are ambiguous figures that can be seen in two ways (e.g., is it a rabbit, or a duck?) that were studied by the 'Gestalt' psychologists who explored how the way humans experience the world has to be understood as more holistic than simply treating perceptual data as if pieces of some jigsaw puzzle that can be put together to give an authentic picture of the world. For example, Figure 2 is an image that can be seen in two different ways.

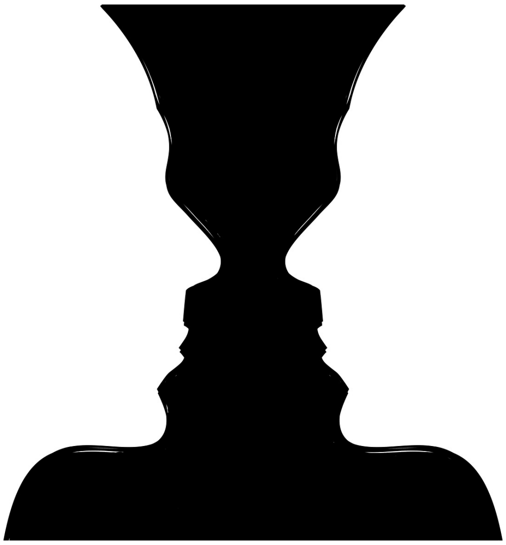

Figure 2. An ambiguous representation (Image by ElisaRiva from Pixabay).

The figure might be seen as two faces (shown in white against a black background). Or the same image (i.e., the same perceptual *data*) could be seen – that is interpreted – as some kind of goblet or candlestick holder (in black against a white background). A person can learn to see either version, but not both at the same time. The brain actively organises perception to make sense of the image, and the viewer can force the 'Gestalt-shift' between the two interpretations. Moreover, during the shift you can 'see' the goblet emerging from the background (or *vice versa*), giving an *impression* of depth.

So, even though I know I am looking at a flat image, I can see the goblet 'move' into the foreground. Perceptual organisation takes place at a preconscious level, not under our deliberate control. Once one has 'seen' a face in cloud formations or in a pattern of craters on the moon, it cannot be simply 'unseen' because *we know* it is just an artefact.

Teachers need to appreciate that perception depends on the brain being primed by prior experience. The teacher might draw or present an image that, to the teacher, *clearly* shows some experimental set-up, plant structure, or three-dimensional configuration of a molecule. But the teacher cannot *assume* that the learners in the class see the same thing. Seeing relies on preconscious brain programming that has been cued by earlier experiences. There are stories of indigenous people being shown photographs or drawings for the first time, but making no sense of them – whilst those same people immediately appreciate the symbolism of their own, familiar, cultural artefacts. Scientists learn to see structures through the microscope or to spot fossil fragments in the field that the untrained observer simply does not see.

Equivalent perceptual data can therefore be organised differently inside different people's brains. Not only does the teacher need to check the learners' interpretations, but she may need to patiently teach the learners a new way of seeing.

Memory

Memory is something that we may tend to *assume* we understand: we 'know' that we store information in memory, and later remember it, but sometimes we forget. As with perception, research shows that the way we talk about memory in everyday discourse is a considerable simplification. We can better think of memory as being some trace of past experience that can potentially change our current behaviour. Educational psychology has produced important findings about how the extent of remembering or forgetting information depends on the number and timing of repeat exposures – something very relevant to both teachers and revising students. More importantly, research suggests that the naive TOM model of memory is not accurate in two important ways (Taber, 2013).

Firstly, memory does not work like 'storage' (where we can enter the store and retrieve the original object), but as forming 'representations' that have to be interpreted later. Memory is 'reconstructive', as those representations are the basis for the preconscious building of a 'memory' that makes sense within our wider understanding. Research shows that memories are not simply present, absent or incomplete, but often quite distorted compared with the original experience that was represented – 'eye witness' testimony has been found to be often unreliable, even when a witness is trying to be completely honest about what they saw.

One study about teaching electrical concepts showed that even when learners' alternative conceptions seemed to be successfully challenged by critical laboratory demonstrations, some weeks later the students were likely to remember having seen the demonstrations as supporting their original deeply-held alternative conceptions (Gauld, 1989). The details of what they had seen were (inadvertently) incorrectly remembered in a way that made better sense to the students.

This is very important for teachers as it shows that learning cannot be assumed to occur by a simple accretion of knowledge, concept by concept, lesson by lesson. Memories are consolidated over time, and are initially fragile (open to becoming inaccessible or being distorted) until there has been sufficient reinforcement. Key ideas need to be revisited throughout the course, so the curriculum has to be designed accordingly.

The second counter-intuitive feature of memory is that it is not really a discrete faculty of mind. What we learn does not just change what we can try to consciously access, but also modifies the functioning of the parts of the brain that filter and interpret perceptual information. We do actually *learn to see* (and hear, etc.) differently through experience.

Cognitive development

Cognition is a blanket term referring to those (preconscious and conscious) processes that support a person in learning and thinking about the world – developing knowledge and understanding. There is much work on various aspects of cognition that is relevant to teaching. A common tool used in planning teaching is to distinguish so-called LOCS and HOCS (lower-order and higher-order cognitive skills). In general, asking a student to undertake tasks such as recalling and applying previously learned information is of lower demand than asking them to analyse, critique or evaluate material, or to solve problems or create new products. Planning teaching needs to be informed by awareness of the stage of development and prior knowledge and skills of the learners; but supporting *development* requires learners to be challenged – which means including tasks requiring HOCS.

There has been much work on problem-solving (Tsapalis, 2021), which is the ability to succeed in tasks that are novel (see Chapter 18). (So, *finding a method* for solving a quadratic equation would be solving a problem, but *applying a previously learned rule or algorithm* would not – even though the outcome is the same.) The very limited capacity of what is known as 'working memory' is critical in determining what learners can achieve. A task that overloads working memory is very likely to lead to failure. Sometimes, people can learn strategies and techniques that can work around these limitations, and learning about this area of research can help teachers to design tasks and assessment items that do not inherently lead to most students failing. Whilst substantive learning depends on learners being challenged, success also depends on providing sufficient support to engage with the challenges. The concept of scaffolding is especially important here, as it suggests how learners can be supported to take on tasks beyond their current competence (important to encourage substantive development), but only with the right kind of structuring and support that can be 'faded' away as the learner develops new competences. Achieving the correct challenge/support balance can be key in facilitating 'flow' experiences – where engagement is such that there is intense concentration and students 'lose themselves' in activities.

There is also research on human thinking that shows that some of the reasoning and logic that is taken for granted in science and technological fields cannot be assumed to be available to young learners. Most famously, the developmental psychologist Jean Piaget characterised aspects of children's thinking at different ages, and identified the kinds of thinking available to children at various stages in their schooling.

Although Piaget's ideas are no longer *fully* accepted, this is in part because further research building on his findings has identified ways of presenting information and tasks to support learners in achieving tasks earlier than would otherwise have been possible (Bliss, 1995). Luria's work has suggested that education influences the forms of thinking available (or at least, usually employed) in a culture. The 'CASE' (*Cognitive Acceleration in Science Education*) project developed tasks to prepare students entering adolescence to master the kinds of thinking needed to engage with the abstract, theoretical side of science (Adey, 1999).

This project also built on the work of the Russian researcher Lev Vygotsky, whose research led to the notion of scaffolding learning – how, in the right social context, students can be supported to develop new skills and thinking by engagement in shared structured activities where they incrementally take on more responsibility for activity. Vygotsky also offered models for helping us understand how a person's knowledge and understanding is built by the *interaction* of direct experience and formal symbolic instruction (that is by doing, *and* also by reading or being told). This has direct relevance for teachers charged with helping learners understand abstract concepts that are not directly linked to what students can immediately experience (that is, much that is taught in science classes).

This area of work is especially relevant for science teachers, who are often charged with presenting highly abstract content that cannot be *directly* demonstrated. This may require learners to undertake mental operations on abstract ideas – just the kind of mentipulation that Piaget suggested only slowly developed during adolescence. Yet, there is now much work showing that teaching approaches can often be found to overcome this. A key notion is that of the educational psychologist David Ausubel (1968), who suggested that the most important factor in a student's learning is what she already knows. The constructivist account of learning has made it clear that, whilst Piaget was right to assume that conceptual development has *its foundations* in direct experience of the material world, that which starts off as abstraction will, with sufficient familiarity, become *as if* concrete over time (so, for a science teacher, a methane molecule, or a food web, or a ray of light has become *as familiar* as any concrete object and can be readily mentipulated). Ausubel referred to *meaningful* learning (contrasted with rote learning), where the learner makes sense of teaching because it is associated with existing knowledge. Teachers can seek to introduce new abstract ideas by showing that they can be understood in terms of the conceptual resources (ideas, images, experiences, etc.) that their students already have available – 'making the unfamiliar familiar' through the common use of metaphor, simile, analogy, personification, anthropomorphism, narrative, etcetera, in teaching.

One important area of research on cognition emphasises how it is often embedded within a social context. This work suggests that we cannot assume that we can transpose the same individual to a different context (perhaps removing them from a context where they have developed and demonstrated some competence) without influencing their ('situated') cognitive processing

(Hennessy, 1993). Context is also important in an 'internal' sense: recent thinking may provide a 'set' that is likely to channel current thinking in a particular way. (This may be of special significance in schooling, where very often the learner in front of the teacher has just come from learning about a completely different discipline.)

Metacognition

Research has also shown the importance of metacognition in higher level learning – that is the ability to be aware of, monitor and direct one's own learning processes – to be able to make one's own thinking the subject of reflection. In a classroom learning situation, the teacher cannot be directly monitoring all the learners at once, so there is great value in a student knowing when they need help, when a change of activity or a break would be more productive than just continuing with an activity, or when they have sufficiently mastered a task and are ready to move on.

Metacognition allows students to be self-directed learners (so, for example, revision is not just endless re-reading of notes) and to take on projects that need to be planned, monitored and evaluated. Students can be supported in using and developing metacognitive skills, and teachers can include 'metacognitive prompts' in instructional materials to remind students to periodically step back from their direct engagement in tasks, to engage in a metacognitive review (Zohar & Barzilai, 2013).

A useful finding for teachers to be aware of is the Dunning-Kruger effect, whereby the least able students tend to over-estimate their achievements (so that they tend to expect that they will do better in a test or exam than proves to be the case). This can be seen as linked to the concept of self-efficacy, which concerns a person's belief in their ability to successfully attain certain goals. Whilst this is an individual characteristic, there may be cultural influences that lead to group effects. For example, students who are aware that they are in a 'bottom set' may believe they have little ability in a subject and cannot achieve anything without continuous step-by-step instruction (despite work being set to match their development and competence) and, certainly historically (and perhaps even today), there has been a tendency for girls to have less self-efficacy in mathematics and physics.

Intelligence

Intelligence is perhaps a classic example of a concept that is widely used in public discourse, but where there is no single, precise, agreed meaning. Most people are aware of IQ, intelligence quotient, as a score obtained from a kind of intelligence test. Testing was first introduced as a means to identify learners in school classes who were not able to benefit (those whom might sometimes be seen today as children with special educational needs), and needed to be separated out for different instruction.

Despite this valuable aim, IQ tests were at one time used to class the population into ability ranges, using terms such as 'idiot', 'imbecile' and 'moron', which came to be adopted as terms of derision. Although IQ was found to be a fairly reliable measure (individuals tend to have fairly stable scores), early IQ tests were found to be culturally biased. They included questions that would only be understood by people sharing particular cultural knowledge (such as how the playing field is laid out in baseball).

It was also found that, over time, the scoring of IQ tests had to be adjusted to avoid the average population score drifting upwards – an indication that IQ scores do not capture something entirely innate, but have reflected global improvements in educational provision. It is sometimes considered that intelligence reflects two components, one reflecting biological features (e.g., how quickly nerve signals are transmitted along nerves) and the other based on an individual's past experience, and so learning.

Intelligence has been modelled in various ways. One approach distinguishes a generalised factor (g), which is characteristic of an individual, but which is moderated in different domains depending on the individual's relative expertise. So, in this model, one would only become a brilliant microbiologist by *both* having a high 'g' *and* by committing time to develop expertise in microbiology. The general factor is also sometimes divided into a 'crystallised' factor (related to applying *prior* learning) and a 'fluid' factor (supporting problem-solving). The theory of multiple intelligences, however, suggests that it is better to consider intelligences as a set of largely discrete characteristics of an individual. Gardner's (1993) model includes: linguistic, logical/mathematical, spatial, bodily-kinaesthetic, musical, interpersonal, intrapersonal, and naturalist intelligences.

According to this model, the IQ test is an incomplete measure of intelligence, as it primarily tests only a subset of these largely independent intelligences (excluding, for example, the 'naturalist' intelligence highly relevant to science learning). The degree of 'modularity of mind' (comprising of largely discrete components, rather than general purpose abilities) remains a debated question. Some other models of intelligence, such as those developed by Sternberg, also downplay IQ. He considers intelligence to be the ability of someone to achieve personally meaningful goals, drawing upon four areas – creativity, analytical ability, practical ability and wisdom – but also by being aware of best utilising personal strengths and weaknesses (i.e., applying metacognition). Teachers should be aware that there is more than one way to define and measure intelligence.

Learning styles

A learning style is a *preferred* way of learning. There are many models of learning styles, but most are only supported by weak empirical evidence that they reflect genuine stable differences between individuals. A very common notion that has been mooted as 'learning style' is known as VAK, suggesting that learners tend to vary on a profile as primarily Visual, Auditory or Kinaesthetic learners. Although very popular, this seems to be largely a misuse of the multiple intelligence concept, and there is no strong basis for seeing these modalities as learning styles.

However, multi-modal teaching (that uses words, images, gesture and practical activity) is potentially very useful, as information received via the different senses can be mutually reinforcing. This is particularly so when images complement spoken information – as long as learners can see how the two are related. Research has led to a model of working memory that includes two small data buffers, one of which can temporarily store a small amount of data originating from the visual system, and the other able to store a small amount of data deriving from the auditory system, as well as a 'space' to mentipulate this data. This potentially allows what is known as 'dual coding', forming associated representations of verbal and imagistic information: something that is considered to aid later recall. As with many such theories in psychology, the entities discussed (the working memory components, the representations) cannot be directly observed, and so evidence is indirect and different interpretations of the evidence are possible. (The same can, of course, be said of many theoretical entities in the *natural* sciences: the Higgs boson, dark matter, mitochondrial Eve, and so forth.)

Gifted learners and differentiation

It has been common in some educational contexts to seek to identify learners who are 'high ability', 'exceptional', 'gifted' or 'talented'. These attempts have usually been well-intentioned, as all students are entitled to educative schooling and students who are more advanced in their learning may sometimes not be sufficiently challenged in standard classes in order to support their development. There is no agreed definition as to what counts as 'gifted', or how to identify the 'gifted' (sometimes IQ tests are used, sometimes teacher recommendations, or diagnostic checklists). Dividing learners into 'gifted' and 'others' (so, not gifted) may be divisive, and may become a self-fulfilling prophecy, as well as a cause of resentment. Also, labelling individuals as 'gifted' may put them under stress if they feel excessive expectations.

Giftedness is better seen as *contextual*, as the student who is seen as gifted in mathematics may not show special abilities in, say, biology, and even within a discipline students have different strengths and weaknesses. Teachers should look to differentiate work such that all students in a class are asked to undertake tasks that they consider challenging, but for which sufficient support is provided to allow them to succeed. This need not always mean differentiating by offering different tasks, but could be differentiating in terms of level of support, or even role. For example, some students may sometimes be asked to act as mentors or tutors to other students; providing that they are comfortable doing so, they are offered support in developing skills in the role, and this is designed as a learning opportunity for the mentor as well as their peers (as preparing for teaching and developing learning materials can be effective and demanding learning activities).

Affect and learner motivation

Whilst science and technology teaching often focuses on cognition – developing knowledge and understanding, problem-solving and the like – the aims of teaching also encompass affective (and aesthetic) values. We want students to develop certain attitudes to the natural world, and to science and technology. Research suggests that just as young people slowly develop more sophisticated cognition during their school careers, they also develop nuanced personal systems of values.

Attitudes are extremely important in education (Potvin & Hasni, 2014). For example, a student who does not value schooling, or does not value a particular school subject, is unlikely to be motivated to commit to a high level of effort. Such attitudes may derive from home values (students from certain backgrounds are given an advantage in education because of the values and attitudes habitually expressed in the home environment).

This may link to personal belief systems about whether formal qualifications are important for adult life, and also to personal beliefs about the self: whether a student thinks of herself as a good student (capable, clever, able, etc.); whether she considers that she has potential in particular curriculum areas (historically, in many contexts, there have been subtle, or even blatant, clues suggesting science and technology are areas more suitable for boys than girls). A student from a home where academic qualifications and schooling are not valued, who does not see themselves as academic, and who thinks that they are part of a group unsuited to science, lacking role models in science and technology, and without ready access to science careers, has little reason to have high expectations of, or to commit to being conscientious and industrious in, science learning. In some cultural contexts, science is often assumed to be a more difficult curriculum area than the humanities or social science. Good teachers may challenge such attitudes and beliefs, but need to be aware that these may be well-established, and that extended positive experiences may be needed to bring about long-term change.

One of the key theorists in motivation theory was Maslow, who proposed a hierarchy of human needs in which the individual is driven to meet the most basic needs (such as food and shelter) before they can focus on higher goals. Even if that is an over-simplification, teachers cannot expect students to concentrate on academic learning when they come to school hungry, or are frightened (perhaps being abused at home or bullied in the playground), or feel unloved (perhaps interpreting a parental break-up as their own fault). The teacher should be alert to such possibilities and, when indicated, involve appropriate other agencies.

Individual differences

Psychology has both identified commonalities among learners (for example, in the general pattern of cognitive development over time) and the importance of individual differences (such as Gardner's notion of profiles of 'intelligences'). One area where the teacher may come into contact with professional educational psychologists is in the identification of learners with special educational needs, such as those who have specific learning difficulties such as dyslexia. Following a tradition that goes back at least to Vygotsky (and indeed Binet's original IQ testing), psychologists have looked to inform teachers about how to best support learning in students with individual differences that may otherwise act as barriers to learning.

In recent years, there has also been increasing attention given to so-called neurodiversity, which is concerned with differences in mental functioning. This covers a range of types of individual differences, including the autism spectrum disorder and indeed such conditions as synaesthesia (where a person experiences somewhat conflated senses). There are many dimensions along which people can vary, and identified groups ('the autistic', 'the gifted', synaesthetes, etc.) may be better understood as those found at the extremes of some of these shared dimensions. That is, neurodiversity refers to ranges of variation on which we can all be located.

Summary

This chapter has introduced some of the wide range of areas in which educational psychology can inform teaching of science and technology. As the examples presented suggest, work in educational psychology links with, and indeed has sometimes motivated, major initiatives in science teaching and STEM curriculum development. Much of the foundational work in educational psychology has, naturally, been carried out by psychologists who see education as a context for research. Whilst applications are often suggested by studies in this field, it is often left to those more centrally working in education to explore implications and develop practical interventions based on psychological research. This often means that educational researchers, teacher developers and curriculum developers in science and technology need to build on the foundational work to develop implementations in classroom practice.

Recommended resources

The following volume includes chapters on a range of educational theories and theorists, including several important perspectives from educational psychology: *Science Education in Theory and Practice: An introductory guide to learning theory,* Akpan, B. & Kennedy, T. (Eds.). (2020). Cham, Switzerland: Springer

A book that develops many of the ideas in this chapter, and offers specific examples of how principles from educational psychology can be applied in science teaching is: *Masterclass in Science Education: Transforming teaching and learning,* Taber, K.S. (2018). London: Bloomsbury

An edited volume looking at affect in science education is *Affective Dimensions in Chemistry Education,* Kahveci, M. & Orgill, M. (Eds.) (2015). Dordrecht: Springer

Various approaches to meeting the needs of gifted learners are discussed in *Policy and Practice in Science Education for the Gifted: Approaches from diverse national contexts,* Sumida, M. & Taber, K.S. (Eds.) (2017). Abingdon, Oxon.: Routledge

Examples of approaches to 'make the unfamiliar familiar' to link science concepts with students' existing conceptual resources can be found at: https://science-education-research.com/teaching-science/constructivist-pedagogy/making-the-unfamiliar-familiar/

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