Executive Functions in Education: controlling the learning brain

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Executive functions – what are they?

If you were to ask three psychologists for a definition of 'executive function' there is a pretty good chance you would get three different answers - executive functions are notoriously 'wooly' to define. Nevertheless, most would agree it centres around our ability to *control* our thoughts and actions in order to respond flexibly to our environment. In other words, all the abilities that enable a person to analyse what they want, how they might get it, and then carry that plan out, often over long periods of time.

Executive functions differ from many other functions in the brain in that they do not appear to be dedicated to a specific task (such as moving a finger or processing sound). Instead, the frontal regions of the brain that play a role in all executive functions are available to make new associations, engage in planning, make decisions and inhibit impulses – mental processes that free an organism up from responding only to an immediate situation. It is also widely accepted that executive functions play a critical part in complex social behaviour, such as understanding how others see us, being tactful, or deceitful.

What is the significance of Executive Functions for education?

Teachers recognise the importance of children being able to control their thinking and self-regulate their behaviour. This focus is well-founded: *children's ability to control attention and action are stronger predictors of academic performance than is IQ, entry-level maths or reading skills.*

In the 1970s and 80s, Walter Mischel, and colleagues at Stanford University, ran a longitudinal study that demonstrated the crucial nature of developing effective executive functions in childhood- a study that is widely known throughout psychology as 'The Marshmallow Experiment'! [1].

Imagine it is 1970 and you are 4-years old, sitting at a table, staring at 2 marshmallows on a plate with a small bell placed besides them. Walter Mischel asks whether you like marshmallows (you do!) and, then, whether they would rather have the one marshmallow or both (again, not too tough a question!). He then tells you that he has to leave the room for a little while and that if you can wait until he comes back you can have both marshmallows. However, if at any point while he is away you decide you can't resist, no problem, just ring the bell and you can have a single sweet. You salivate, sit on your hands, even lick around the plates, but more often than not you hold out for a few minutes before ringing the bell.

Moving forward 15 years, Mischel sends a questionnaires to your parents asking them to report on your personality, ability to deal with frustration and delay gratification. Mischel discovers that the number of seconds you waited to ring the bell in 1970 predicts not only what only your parents say about you as a teenager but also the likelihood that you were admitted to a top university. The "grabbers" are found to suffer lower self-esteem and are viewed by others as more stubborn, prone to envy and easily frustrated. The "waiters" are better copers, more socially competent and self-assertive, trustworthy and more academically successful, scoring significantly higher on their college entrance exams (SATs). The inhibitory control demonstrated in this experiment fits classically into an executive type of function and sets the tone for the importance of executive functions for effective development.

Executive functions in the classroom

Over the last year we have run a pilot-project at Oxford University with a group of teachers, exploring how some scientific perspective in learning can be of use to them in developing their practice (http://www.futuremind.ox.ac.uk/impact/education.html). One of the key areas that jumped out as important to the group was that of 'executive function', as they recognised the direct significance of good cognitive control skills for the classroom.

Executive function skills are found to be central to many educational domains. Although by no means exclusive, this includes adolescence, early-years development, 'gifted and talented', development disorders (ADHD, ADD), Learning and Thinking Skills, memory and creativity (see below for further details).

We expect there is potential to develop some very interesting, and potentially powerful, teaching strategies by combining the scientific insights with practical expertise around these areas.

Early years

Cognitive control abilities in early-years are a better predictor of school readiness than either IQ, entry-level maths or reading ability [2]. It is also possible to improve early-years EF abilities by altering environmental factors. For example, the 'Tools of the Mind' programme (US) is an exciting intervention programme that delivers direct improvements in cognitive control in pre-school children [3]. What other educational strategies and interventions might be possible with this age group to improve EF skills?

Gifted and Talented

Effective cognitive control skills are central to G&T children's abilities. When considering young gifted musicians, Professor John Geake, from Oxford Brookes University, reports that "*it is their superior use of executive or metacognitive strategies [mediated by the frontal cortex], such as inward-directed attention, that contributes most towards their remarkable abilities.*" [5].

How do these findings relate to teaching strategies with 'gifted and talented' kids? Can these skills be explicitly developed?

Creativity

The ability to move between focused and broadened states of attention is thought to be central to creative thinking. As such, it may be possible to apply cognitive models of creativity to develop pedagogical strategies for improved creative thinking in learning environments [6].

ICT and attention

Digital technologies can have a powerful impact on attention in young people. When used appropriately, educational technologies can deliver powerful motivational and attentional gains, however, educational softwares can also distract away from core learning [4]. How can we apply our understanding of executive function to make best use of digital technologies in different learning environments?

Adolescence

The frontal lobes that form the seat of executive functions in the brain undergo major structural reorganisation throughout adolescence. Concurrently, executive function skills continue to develop during this period [7]. Should it be an explicit goal of education to develop these skills and abilities over this period? How do we adjust task demands during teaching according to the neurological maturity during adolescence?

'Learning to Learn' strategies

'Learning to learn' programmes which focus on developing metacognitive learning strategies - problem solving, hypothesising, and handling data etc - draw heavily on executive function abilities. There would appear to be a natural synergy in combining these pedagogical approaches with the scientific insights around executive functions.

References

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