Chapter 13
Introduction to Part IV: Development and Learning

This part of the book will build upon the earlier chapters to consider how we can model development and learning in science education. Part II explored the idea of the learner as a cognitive system. It built up a model of how the individual can take in and process information from the environment and then represent the output of cognition in the public space. It was argued that an important feature of the human learner as a cognitive system is the intimate relationship between *the apparatus* of cognition and cognitive *processing*: that is, that the processing of new data through the existing cognitive apparatus has the potential to modify the apparatus itself.

The first chapter in this present part (Chap. 14) will consider cognitive development: the way our cognitive processes become more sophisticated so that the cognitive apparatus of the adult is qualitatively different from that of the neonate. Part III looked in some detail at what we might understand as knowledge in the context of a human learner. In particular, it considered important distinctions such as that between implicit and explicit conceptual knowledge and the notion of how a person's conceptual knowledge can be understood to be organised into a 'conceptual structure'.

The second chapter in this part (Chap. 15) considers how conceptual knowledge changes as a result of cognitive processing. At a gross level, these two chapters are about different things, as one is about how the cognitive apparatus develops and the other is about how we can change the knowledge represented in the cognitive system. However, that is clearly not an absolute distinction given the intimate relationship discussed above.

So, for example, when perceptions are interpreted through what have become automatic processing components such as p-prims (see Chap. 11) developed by abstraction from common general patterns, then we might think of these processing components as part of the cognitive apparatus. However, they are also representing implicit knowledge that has been acquired (constructed) by the system. They are both part of the machinery of knowledge acquisition and also previously established

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Table 13.1 A model of the first-order distinction between development and learning

	Cognitive development	Conceptual learning
Is primarily about	Changes in kind of thinking available	Changes in knowledge represented
Depends upon	Largely under genetic control, but supported by normal experiences common to environments where humans develop	Limited by cognitive development, but dependent upon specific resources in the environment
Path	General nature is common for all human development	Highly contingent, leading to somewhat idiosyncratic outcomes

elements of acquired knowledge. As described earlier, a person's memory is not a discrete store accessed by his or her processing apparatus but rather an integrated part of that apparatus. In effect our brains work in a way that prioritises supporting the ability to provide an interpretation of current experience informed by our previous experiences rather than having access to a high-fidelity record of those past experiences.

Despite this complication, it is useful to separate out cognitive development from conceptual learning, at least as a first-order simplification. To some extent there is a link here with nature/nurture issues, as can be seen from Table 13.1.

Discussions of the relative importance of genetic and environmental factors can become emotionally charged as, for example, when considering such matters as the role genetic factors might play in explaining criminal behaviour or the significance of sex for aptitude for science. Arguments setting out whether nature or nurture is more important may sometimes seem to miss the point that there is no absolute way to measure similarity in either genetic make-up or environment conditions. The extent to which genetics or environment is more significant in determining whether individuals can be successful on verbal intelligence items, for example, will look rather different when the 'individuals' are all 'normal' human beings, rather than a mixture of humans, chimpanzees and orangutans. If that seems a contrived example because 'of course' we are only interested in humans, then we need to bear in mind that what makes an individual a human rather than an orangutan is their genetics, and that all people have sets of genes that have a great deal in common.

To offer extreme examples, if a new born baby was ejected into space without an environmental suit, then environmental rather than genetic factors would dominate the course of the hypothetical baby's (tragically short) development and learning compared with other learners in more typical environments; just as an orange tree's classroom learning would be extremely limited by its genetics, regardless of the quality of the 'learning environment' and teaching in the class.

Bearing in mind, then, the proviso that all processes of development and learning are the result of interactions between genes and environment, Table 13.1 offers a model of a first-order distinction between two types of change that human cognition undergoes. These types of processes are commonly referred to as cognitive development and conceptual development, but it can sometimes be useful to actually distinguish between them by using the term development for one and learning for the other.

Thinking of Development as Under Genetic Control

A key distinction then between development and learning is that development can be understood to be largely a 'normal' process that humans will undergo so that in general terms we all follow much the same path of development. So neonates tend to have very similar cognitive abilities, and by adulthood these have generally developed in much the same way in nearly all of us, even if the extent of development may be greater in some than others (see Chap. 14). There is a danger of tautology here in suggesting that all normal individuals follow the same developmental path: whilst excluding from the category 'normal' anyone who does not. Some severely retarded individuals never fully develop normal adult thinking abilities, something that is understood to be due to genetic deficiencies or some form of 'damage' to the cognitive apparatus - such as, for example, might be due to insufficient oxygen reaching the brain during a problematic birth.

We might think of development being 'under genetic control' in the sense that all 'normal' (sic) humans have the genetic resources to facilitate a particular general developmental path subject to typical environmental conditions – where 'oxygen starvation' would represent an atypical environmental condition for human development. So this is certainly not to say that the environment does not play a major role in development, but rather that the necessary features of the environment required to support 'normal' development tend to be common enough not to be a limiting factor, and that, in particular, there is considerable redundancy in the precise stimuli and experiences which are able to provide such support. The developing child needs experience of objects to push and pull and squeeze and so forth to support normal development, but a small selection of the wide range of particular objects potentially available would suffice to do the job.

Thinking of Learning as Learning Environmentally Contingent

By contrast, we can think of learning as being primarily contingent upon specific learning opportunities. Whereas acquiring certain cognitive abilities is supported by a wide range of environments, learning Newton's laws of motion or orbital models of atomic structure, or the theory of natural selection, is much less likely to happen to occur 'by chance' and is indeed only likely to occur in particular cultural contexts where environments are especially engineered to support this specific learning. And even then, as we have seen, acquired understanding will not necessarily match intended understanding.

Again, this is not to ignore genetic factors. Newtonian mechanics, atomic structure and evolutionary theory will only be learnt by those who have developed suitable cognitive apparatus through the genetically driven processes of development discussed above. Our orange tree would not make progress here and indeed nor would our orangutan. So in both the cases of cognitive development and conceptual learning, genetics and environment are essential, but to a first approximation we can identity situations where we can largely take one or the other as given.