Chapter 8
Introduction to Part III: Knowledge in a Cognitive System Approach

> In short, the interviewer is constructing a model of the child's notions and operations. Inevitably, that model will be constructed, not out of the child's conceptual elements, but out of conceptual elements that are the interviewer's own. (Glasersfeld, 1983, p. 62)

The previous part of this book explored mental notions – such as ideas and understanding – and how these might be understood in terms that support modelling of research into aspects of learning in science (see Fig. 7.6).

Key ideas arising from this exploration of mental constructs were:

- As subjective experience is only available to the individual, any research claiming to report the ideas or understanding or beliefs, etc. of a learner must be based on interpretations made by researchers of public representations of the learner's mental experiences in the external world.
- There is a range of common terms such as thinking, memory and understanding which are widely used to discuss mental phenomena but make up a lifeworld register of signifiers of fuzzy concepts, and which when used in research reports without further clarification can compromise the precise communication expected in technical writing.
- Mental phenomena can be understood as correlates of physico-chemical processes in human nervous systems that ultimately relate to electrical activity occurring in networks of neurons.
- But mental experience is an emergent property of the complex nature of the nervous system and in particular the brain, making descriptions at the physiological level generally less helpful in research into learning in science.
- However, a more fertile approach is to model the learner as a cognitive system that processes information, but where such a model is *constrained by* what is learnt from anatomical and neuroscientific studies, as well as from psychology and science education research.

K.S. Taber, *Modelling Learners and Learning in Science Education: Developing Representations of Concepts, Conceptual Structure and Conceptual Change to Inform Teaching and Research*, DOI 10.1007/978-94-007-7648-7_8,

The Cognitive System Approach

Figure 8.1 sets out an overview, in the form of a kind of concept map (Novak, 1990a), of how one might conceptualise the learner as an organism that is supported in the 'task' of surviving in an environment by a cognitive system that enables the individual to sense the environment and act in, and so on, it. The individual is a *learner* as he/she is able to use this feedback to modify action because of the plasticity of the system.

That is, the cognitive structure through which processing occurs when sensory information informs action is itself modified by experience (see Chap. 5). The bolder arrows in the figure constitute the basis for a feedback cycle: information about the environment and/or the internal state of the organism is processed to direct behaviour that changes the environment and/or the internal state of the organism, and then new information about the environment and/or the internal state of the organism allows that change to be detected. To support this process, our sensory/ perceptual apparatus is especially tuned to notice changes – movements in the visual field, variations of tone or volume, etc.

The overall approach taken here is hardly original and, for example, has much in common with the way that Piaget (1970/1972) thought about young children learning to make sense of their environment. Piaget approached his seminal programme of work on cognitive development with the perspective of a biologist, and recognised that it was productive for understanding children as developing people to consider that they were also biological organisms (with the constraints and

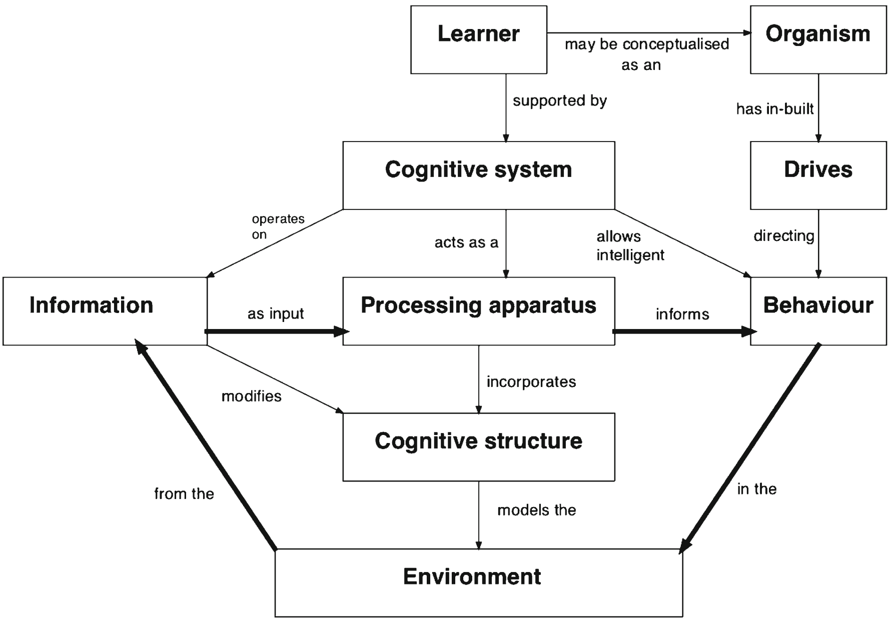

Fig. 8.1 The organism in the environment supported by a cognitive system

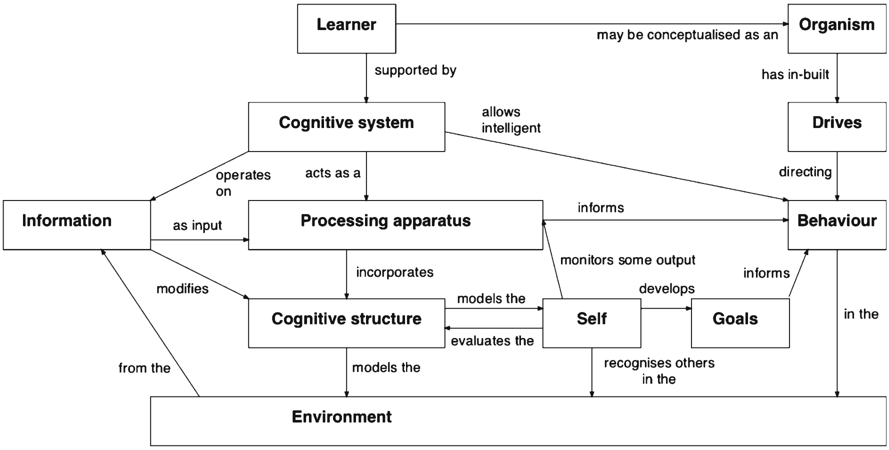

Fig. 8.2 The conscious organism can include itself as a discrete element within its model of the environment

affordances that implied), and so came to be as they were in considerable part because of natural selection acting over extended periods (Piaget, 1979).

Taking a biological perspective as his starting point may have contributed to common criticisms of Piaget as underplaying the role of socialisation in development. Indeed, the conceptualisation presented in Fig. 8.1 need not refer to a human learner, but would apply to any organism with a complex enough nervous system to move beyond purely instinctive behaviour which can only be selected upon at the generational level by natural selection, to be able to modify its own behaviour in response to feedback from the environment, when acting to meet its needs. Such an organism, by modifying (tuning) synaptic connections within its nervous system (see Chap. 7), will learn from experience and may be considered to be modelling the environment to inform future action. This need not require conscious awareness, but should be considered a form of intelligent behaviour, where intelligence is fundamentally the ability to learn from experience. Consciousness, however, enhances this system, as suggested in Fig. 8.2.

Consciousness provides awareness of self as separate from the environment, allowing deliberate goal-directed behaviour. Awareness of self also supports the development of a ‘theory of mind’ (see Chap. 2), which allows us to identify others as discrete elements of the environment to which we can posit needs, emotions, ideas, etc. The extent to which we are likely to be able to effectively model the minds, that is, the conscious experience, of those others depends to a large extent on how like us they are. The philosopher Thomas Nagel (1974) famously argued that although we have good reason to assume that a bat has a sophisticated enough nervous system to be conscious, and so it is meaningful to talk of *what it is like to be a bat*, there was no way that a human being with his or her very different nervous system, and in particular sensory system and cognitive apparatus to support it, could ever know what it is was like to be a bat.

Awareness of self as a conscious actor in the world also allows the development of metacognition, which it was suggested in the previous chapter, provides the facility to monitor, reflect upon and evaluate our own cognition. Thus, the metacognitive being not only learns from feedback about actions in the world, but can also learn from feedback about cognitive processes themselves.

Linking Back to the Mental Register

In the previous part a number of key themes were explored, taking terms from the lifeworld mental register and considering how they could be understood in terms of a model of the learner as a cognitive system. Terms such as perception, ideas, memory, understanding and thinking have been discussed from this perspective and can be mapped onto different parts of Fig. 8.2 – as has been done in Fig. 8.3:

Seeking to Understand 'Knowledge' Within the Cognitive System Approach

Another key term in the lifeworld mental register is 'knowledge', which – like the other terms considered in the chapters in Part II – is widely used in everyday communication, both in lay and professional educational contexts, but again proves difficult to pin down to a precise meaning.

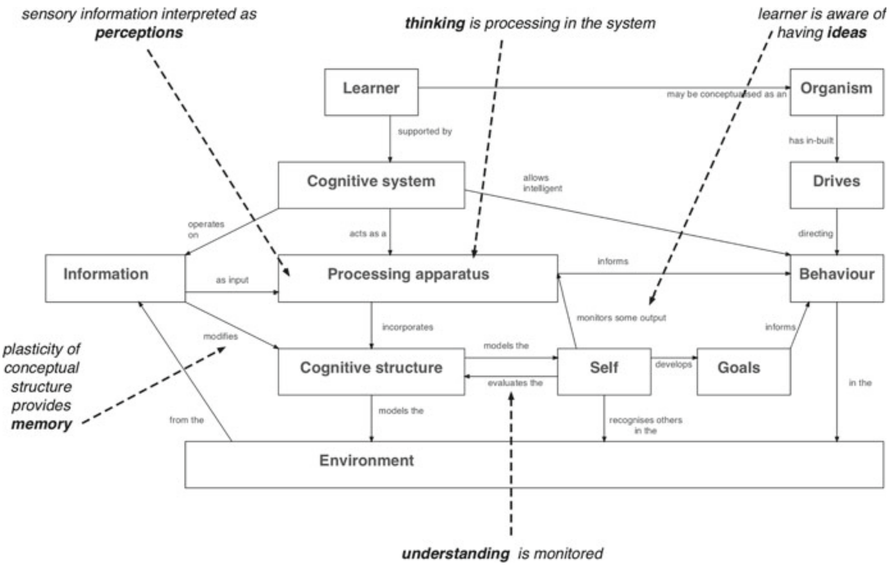

Fig. 8.3 Linking the cognitive system description to the mental register

A particular problem with the notion of knowledge, as widely used, is that the term is applied to mean:

- Something which is an attribute of individuals: the students’ knowledge of science topic X
- Something which exists in the public sphere: scientific knowledge

This presents a particular difficulty for the analysis being followed in this book. An individual’s knowledge can be understood in terms of the cognitive system approach, as with terms such as understanding and memory (as in Fig. 8.3), but it is more difficult to see how knowledge – if understood in these terms – can also be said to exist in the public space between individuals.

The chapters in this part seek to take forward the analysis presented in Part II. The next chapter, Chap. 9, addresses the core issue of what is the nature of a learner’s knowledge, examining various meanings that have been given to the term, before suggesting how knowledge can best be understood as part of a cognitive system. Although the concern of the present book is modelling *the learner and learning*, the learner’s knowledge is commonly judged in education against what is understood to be scientific knowledge, so the relationship between personal and public knowledge offers a challenge for the approach adopted here.

One sense of the term ‘public’ knowledge is that it refers to what is generally known, rather than being private information, but whilst this is a useful notion, it is clearly problematic. For one thing, the public is a large body, so there is likely to be little knowledge that can be considered to be known by everyone. Public knowledge is therefore better understood as knowledge that is widely known and generally accessible through being represented in the distributed system of the network of people. We can ask someone, ‘look it up’ in a book, or perhaps more often these days, use an Internet search engine.

If something is public knowledge, in the sense that it is widely known, then that might seem to imply that many people have *the same* knowledge. This might seem a reasonable suggestion if we are interested in ‘factual’ information such as the answers to questions such as who is the current president of the European Union, what do the initials NARST stand for and where is Pitcairn Island? However, there is a problem if we are interested in the more complex information needed to answer such questions as how does photosynthesis work, why did the dinosaurs become extinct and what is the molecular structure of benzene? Here knowledge depends upon understanding that we have seen (Chap. 6) is nuanced and may be quite idiosyncratic. It would not be sensible to expect the ‘same’ knowledge to be held by many different people in such cases. Clearly, the very notion of ‘public knowledge’ is a problematic one. The issue of how the personal knowledge of an individual relates to notions of public knowledge such as scientific knowledge is taken up in Chap. 10.

The final chapters of this part then shift the focus back to the individual learner. Chapter 11 tackles a long-standing issue in science education research, that is, of the nature of the different kinds of knowledge components reported in research, and sets out a model (mindful of what has been established in Part II) for making sense of these different types of knowledge element. Finally, Chap. 12 considers another key referent in some science education research, conceptual or cognitive structure, and explores how aspects of an individual's knowledge might be organised within some kind of structure.