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Author
Sweller, John

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Instructional Implications of Natural Information Processing Systems

John Sweller (j.sweller@unsw.edu.au)
School of Education, University of New South Wales, Sydney, NSW 2052, Australia

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Natural Information Processing Systems

Natural information processing systems are a class of systems that can be found in nature. Biological evolution and human cognition provide examples of such systems (Sweller, 2003). It is suggested that all natural information processing systems may have a similar underlying logic. If the basic processes of biological evolution and human cognition are shared, it may be possible to use the mechanisms of biological evolution to throw light on critical aspects of human cognition that are relevant to instruction.

Some Principles Common to Natural Information Processing Systems

The Information Store Principle. Natural information stores deal with the complexities found in nature by storing huge amounts of information. A genome provides that store of information in the case of biological evolution. LTM provides a similar function in human cognition. Our understanding of the function of LTM may be traced to the work on chess by De Groot (1965) and Chase and Simon (1973) who provided evidence that the moves made by chess players were primarily determined by information stored in LTM. This finding suggests that LTM contains a large amount of information that governs cognitive activity.

The Borrowing Principle. Any genome borrows almost its entire structure from its immediate ancestors using the processes of reproduction. Similarly, in human cognition, the borrowing principle constitutes the most common form of learning. For any individual, learning by assimilating knowledge constructed by others is necessarily the norm. Knowledge, held in LTM, can be communicated to the LTM of others indefinitely either by a process of imitation or in spoken or written form. It is that communication that inevitably constitutes the bulk of knowledge acquisition.

The Randomness as Genesis Principle. The borrowing principle only communicates rather than constructs information, In natural information processing systems, random generation followed by effectiveness testing is the only process by which the store of information can be initially built. All genomes were initiated solely by a process of random mutation because natural information processing systems cannot have an executive structure that determines what alterations to the store of information are to be considered (Sweller, 2003). Testing after the event can determine what will be retained but there is no executive process that can determine what future alterations to the store of information might be beneficial before the event.

This procedure may also be unavoidable in human cognition. During problem solving, we use a combination of previously acquired knowledge and random generation followed by tests for effectiveness. Randomly generated moves can be mentally tested for effectiveness but their potential effectiveness cannot be determined prior to their being generated. There is no executive system that could make such a determination (Sweller, 2003). Thus, in the absence of knowledge, moves must be randomly generated first and then tested for effectiveness. Information held in LTM initially had to be produced by this generate and test process. On this argument, random generation followed by effectiveness testing is the genesis of all information held by natural information processing systems.

The Narrow Limits of Change Principle. Because of the random elements associated with altering the information store of natural information processing systems, any alterations to the store must be small. A large random change is likely to destroy the functionality of the store.

WM ensures that alterations to LTM at any given time are small. WM limitations only apply to novel information coming via sensory memory. WM limitations disappear when dealing with previously organised information coming from LTM (Ericsson & Kintsch 1995) that is not intended to change the LTM store.

Instructional Implications

The information store principle suggests that the primary function of instruction is to facilitate knowledge acquisition. The borrowing principle suggests almost all knowledge is learned from others rather than discovered for ourselves. Discovery occurs over generations and follows the randomness as genesis principle. The random components of discovery ensure the process cannot be taught, in contrast to knowledge held in LTM that can be taught. Cognitive load theory was developed as an instructional theory that indicates how to present information structured according to the narrow limits of change principle to reduce unnecessary WM load and facilitate change in LTM (see Sweller, 2003 for a summary of cognitive load theory effects).

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