Theories of Learning and Computer-Mediated Instructional Technologies

David Hung, *Singapore*

Abstracts

The aim of this paper is to describe the dominant schools of thought in relation to learning theories and how computer-mediated technologies can be integrated in relation to these theories. A framework is proposed for integrating the learning theories, situating the use of these learning theories in different instructional contexts. Hence, instead of regarding the learning theories as discordant, it is rather proposed that human cognition is complex and that there is a role for behaviourist, cognitivist, constructivist and social constructivist models of learning based on the objectives and context of learning. Moreover, computer-mediated instructional technologies can also be appropriated accordingly based on the different contexts of learning and instruction.

Théories de l'apprentissage et technologies numériques.
Cet article tente de décrire les différentes écoles de pensées relatives aux théories de l'apprentissage et de l'intégration des nouvelles technologies numériques. Nous proposons de situer les diverses applications de ces théories dans divers contextes d'enseignement. Sans mettre en opposition ces théories, nous tentons de démontrer la complexité de la connaissance humaine, tout en montrant le rôle des divers modèles d'apprentissage, behavioristes, cognitivistes ou socio-constructivistes et dans quelles mesures l'usage des technologies numériques peut s'y intégrer.

Lerntheorien und computervermittelte Unterrichtstechniken
Das Ziel dieses Beitrags ist, die dominierenden Denkschulen in Bezug auf Lerntheorien und wie computervermittelte Techniken in diese Theorien eingefügt werden können, zu beschreiben. Wir schlagen einen Rahmen vor, in den die Lerntheorien integriert sind, und der ihre Verwendung in verschiedenen Unterrichtskontexten darlegt. Daher schlagen wir vor, statt die Lerntheorien als disharmonisch zu betrachten, lieber darauf abzustellen, dass menschliches Erkennungsvermögen komplex ist, und dass dabei Platz für Behavioristen, Kognitivisten, Konstruktivisten und Sozialkonstruktivisten ist, ihre Lernmodelle auf die Ziele und den Kontext des Lernens anzusetzen. Außerdem können computervermittelte Unterrichtstechniken auch angemessen auf Grundlage der verschiedenen Kontexte von Lehren und Lernen reflektiert werden.

Introduction

In this paper, we will be describing four major models of learning: behaviourism, cognitivism, constructivism and social constructivism. Based on these models, we will conceptualize a framework categorizing computer-mediated tools to learning theories. Fundamentally, we adopt the perspective of complementing the use of the above models of learning based on the instructional objectives and context engineered by the teacher and appropriated by the learner. More specifically, we make a distinction between learning theories (or cognitive paradigms) and instructional approaches. The issue at hand is which instructional method would 'most efficiently' enable knowledge to be learned and understood.

Behaviourism and cognitivism

Fundamentally, the behaviourist model is derived from the stimulus and response theory of Skinner. Under this paradigm, the learner is conditioned to respond based on a stimulus. Behaviourism viewed behaving organisms as a 'black box,' and 'inner processes' were of no concern (Skinner, 1974). Skinner argued that since it is not possible

Education Media International
ISSN 0952-3987 print/ISSN 1469-5790 online © 2001 International Council for Education Media
http://www.tandf.co.uk/journals
DOI: 10.1080/0952398011010511 4

to prove the inner processes with any available scientific procedures, researchers should concentrate instead on 'cause-and-effect relationships' that could be established by observation. Working within the broad behaviourist framework, however, Tolman found experimental evidence that rats formed certain patterns or 'representations' of the mazes through which they were running. The notion of 'representations' was developed in the arena of AI (artificial intelligence) of which sprang *cognitivism*. Knowledge is a storehouse of representations, which can be called upon for use in reasoning and which can be translated into language. Thinking is a process of manipulating representations (Winograd and Flores, 1986). The mind was perceived as an information processor with short-term and long-term memories, including a working memory.

Situated cognition

The recent rise in situated cognition directly refutes the premises of cognitivism, particularly the cognitivists' foundations of objectivism and knowledge as distinct and abstract. Instead, meanings are to be taken as relations among situations and verbal or gestural actions (Clancey, 1992). Such a view stresses an inextricable link between contextual constraints (i.e. social, historical and cultural) and the acquisition of knowledge (Bredo, 1994; Brown *et al.*, 1989; Coulter, 1991; Greeno, 1991; Prawat, 1996; Rowe, 1991).

In other words, mind is perceived as an aspect of person-environment interaction, where activity involves a transaction between person and environment that changes both (Dewey and Bentley, 1949). Dewey focused on 'doings and underdoings', which reciprocally change the character or structure of both person and environment, creating a joint history of development. Bateson viewed such a process as a series of interactional cycles (Bateson, 1972, 1979).

In the context of the above, situated cognition implies that the activities of person and environment are parts of a mutually constructed whole. Viewed actively, the adaptation of person and environment involves mutual modification rather than static matching (as in cognitivism). Such an 'interactivist' (Bickhard, 1992), 'relational' (Lave and Wenger, 1991), 'dialectical' (Clancey, 1991) or 'transactional' (Dewey and Bentley, 1949) view focuses on *processes* in interactivity. Work related to this perspective includes Vygotsky's socio-historical approach (Newman *et al.*, 1989; Rogoff and Lave, 1984), Garfinkel's ethnomethodology and later works on conversational analysis (Suchman, 1987) and evolutionary epistemology (Bateson, 1972, 1979).

Constructivism and social constructivism

The dominant educational schools of thought focusing on processes and interactions, whether individually or socially, are the constructivist and social constructivist paradigms of learning respectively. The constructive paradigm, as advocated by Piaget (1960) and Bruner (1990), stress the notion that whatever gets into the mind has to be constructed by the individual through knowledge discovery (Piaget, 1960/1981) with a focus on the process of assimilation and accommodation of knowledge. In other words, meanings are perceived as inseparable from one's own interpretation (Clancey and Roschelle, 1991; Dewey, 1910/1981; Prawat, 1996; Reese, 1991; Roschelle, 1989; Still and Costall, 1991; Tyler, 1978). Its emphasis is not in the interactions of the individual with the environment (including other social beings) but more on how the mind constructs knowledge. Although there may be many different versions of what constructivism entails, the general view held is that learning is an active process of constructing rather than acquiring knowledge. Knowledge is not just a mental state; rather, 'it is an experienced relation of things, and it has no meaning outside of such relations' (Dewey, 1910/1981, p. 185).

More recently, the social orientations of constructivism commonly linked to Vygotsky (e.g. Vygotsky, 1978) and neo-marxist theories of practice (e.g. Lave, 1988; Lave and Wenger, 1991) have gained wide currency. Vygotsky emphasized the cultural and social context influencing learning. Vygotsky's brand of constructivism is called social constructivism because he emphasized the critical importance of interaction with people – other children, parents and teachers – in cognitive development.

Similarly, a situated view also tends to see language as a means for social co-ordination and adaptation (Maturana and Varela, 1987). Language can be perceived as a tool for pursuing particular lines of inquiry needing to be viewed in its contexts. Society, through the use of language and other artefacts, shapes the individual's view of reality. Through language, members of a discourse community learn to 'carve out' the world in similar ways; they develop similar 'anticipations' about external reality. From such a perspective, human learning is best understood as a process of human languaging (Maturana and Varela, 1987). The process of languaging has not only the function of reaching understanding, but also of co-ordinating action and socializing actors as well. This brings forth a network of conversation and dialogue. In a very real sense, human learning is human languaging, the exchange of conversation and dialogue.

In summary, social constructivism focuses on relations in actions and situations through meaning negotiation, where participants orient themselves in their efforts in reaching intersubjectivity or shared meanings (Barwise and Perry, 1983; Roschelle, 1992; Vygotsky, 1978, 1981). Where constructivism emphasizes cognition as an individual activity and 'in the head', social constructivism focuses mostly on knowledge socially constructed 'in the world'. Hence, the individual dimensions are seemingly neglected. In summary, the general view of social constructivism is that human knowledge is socially constructed, and the interpretation of knowledge must be dependent on the cultural and social context through which the knowledge was constructed. Balancing the two predominant schools of thought – constructivism and social constructivism – is an emphasis on both the social and individual dimensions of cognition. Adopting the general premises of both schools of thought, we have:

(1) Learning is an active process of constructing rather than acquiring knowledge;
(2) Knowledge can be socially constructed where the social interactant may include just oneself;
(3) The interpretation of knowledge is dependent on (a) the prior knowledge and beliefs held in one's own mind and (b) the cultural and social context through which the knowledge was constructed.

Table 1 summarizes the major learning theories and their general orientations with an example on learning the concept of multiplication. The main concepts of the learning theories are summarized in table 2.

Learning theories, instructional approaches and technologies

From the perspective of cognitive and learning theories, the different models seem mutually exclusive. With all the idiosyncrasies of the above paradigms, some educators are beginning to discard some of the predominant approaches of one paradigm (e.g. direct instruction as advocated by cognitivists) in favour of activities advocated by others (e.g. discussion that foster the social construction of knowledge). For a more balanced perspective, we should make a distinction between learning paradigms and instructional approaches. Here, cognitive paradigms try to describe the cognitive apparatus through which we learn and acquire knowledge, whereas instructional approaches are methods of instruction for learning. Hence, for example, if the cognitive (i.e. where the cognitive apparatus is assumed to absorb knowledge through transmission) paradigm is problematic, it does not mean that we should throw out the notion of direct instruction as an instructional approach. The argument here is that if whatever gets into the head is 'constructed', according to the constructivist paradigm, knowledge seemingly 'transmitted' into students' minds through direct instruction still has to be 'constructed' by the student.

On the other hand, the social constructivist paradigm views knowledge where meanings are socially constructed and based on cultural perceptions. This implies that learning is the result of a process of inquiry, whether at the individual and/or social level (Dewey, 1910/1981). For students to engage in the learning process, there is no

Table 1 *Summary of theories of learning with examples*

Behavourism	**Stimulus and response** – Students remember and respond (change in overt behaviour due to conditioning) – Teachers present and provide for practice and feedback	e.g. 8*5 = 40
Cognitivism	**Information transmission and processing** – Students remember strategies, rules and patterns – Teachers plan for cognitive learning strategies	e.g. 8*5 equals 5*8 = 40; or n*1=n
Constructivism	**Personal discovery of knowledge** – Discover relationships between concepts, e.g. addition and subtraction – Teachers provide instructional context for active and self-regulated students	e.g. 8*5=8+8+8+8+8
Social constructivism	**Learning is a social construction, mediated by different perspectives** – Through authentic projects, students discuss and discover meanings, e.g. concept of multiplication – Teachers provide for facilitation and scaffolds among the students	e.g. two job offers; same salary: Option 1: 8 hrs/day for six days/week Option 2: 9 hrs/day for five days/week

Table 2 *Key concepts of dominant learning theories*

	Behaviourist	**Cognitivist**	**Constructivist**	**Social constructivist**
Learning	Stimulus and response	Transmitting and processing of knowledge and strategies	Personal discovery and experimentations	Mediation of different perspectives through language
Type of learning	Memorizing and responding	Memorizing and application of rules	Problem solving in realistic and investigative situations	Collaborative learning and problem solving
Instructional strategies	Present for practice and feedback	Plan for cognitive learning strategies	Provide for active and self-regulated learner	Provide for scaffolds in the learning process
Key concepts	Reinforcement	Reproduction and elaboration	Personal discovery generally from first principles	Discovering different perspectives and shared meanings

contradiction for the use of instructive approaches complemented with other constructivist approaches. For example, ground rules and other foundational knowledge (e.g. alphabets and their sequence) can be 'told' explicitly to students before they engage in constructivist and social constructivist activities. Here, it does not mean that foundational knowledge cannot be learned through constructive methods. There is basically no 'true objectivism' in the best method. We approach the issue with pragmatism.

Students can extend on knowledge gained and further experience the relationship of concepts as they construct meanings among themselves. The issue, then, is how students can best learn from the various instructional approaches adopted in the classroom, and the balance accorded to each approach. Our view, then, is in situating the instructive and constructive approaches within the broader social constructivist framework.

The recent directions in computer-mediated tools and instructional technologies have been from individually-centred to socially-oriented environments and closed systems to generically-based tools. For example, in the past, many computer-based applications are individualized tutorial, drill and practice, and simulation software, whereas in recent times, we are beginning to see environments that enable interactants to communicate with one another. Tutorial and drill and practice software are usually closed-ended, bounded by the content and context defined by the software. On the contrary, simulations, collaborative environments and tools (e.g. Microsoft Word and Excel) are open-ended environments. Table 3 illustrates the kinds of computer-mediated tools with the respective learning theory.

From the above discussion, technologies can range from tutorial-type direct-instruction applications (for example, CBLs) to social constructivistic environments fostering knowledge construction. These kinds of instructional environments can be classified into:

- Individual instructive tools;
- Informative tools;
- Individual constructive tools;
- Social communicative tools;
- Social constructive tools (see figure 1).

Examples of *individual instructive tools* include traditional tutorial and drill and practice types of programmes. They are typically designed to be used by individuals and are good tools for supporting basic information and knowledge such as the multiplication table. *Informative tools* provide necessary materials and resources for students to construct their knowledge. Examples of such technologies include encyclopaedias and Internet resources. These tools support the generation of ideas and can provide students with information based on different perspectives. Moreover, these tools also serve as good external sources where students can counter-check the

Table 3 *Computer-mediated tools and learning theories*

Behaviourism	Variety of drill and practice computer-based learning software	For example, CBLs that drill students on multiplication and addition (individual instructive tools)
Cognitivism	Tutorials and information databases	For example, encyclopaedia and Internet resources (informative tools)
Constructivism	Individual generic purpose tools	For example, Excel, Word and PowerPoint, simulations, hypertext and hypermedia, organizational tools (individual constructive tools)
Social constructivism	Collaborative generic environments	For example, e-mails, bulletin boards, knowledge co-construction/exchange forums, computer-mediated collaborative problem solving environments (social communicative/constructive tools)

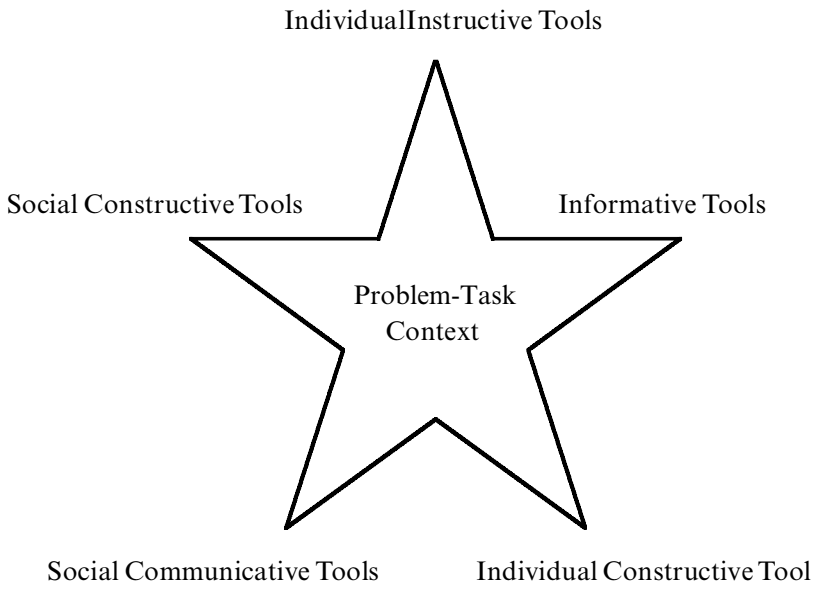

Figure 1 *Five kinds of tools*

validity of their knowledge negotiations. *Individual constructive tools* are multimedia authoring tools, spreadsheets, word processors, simulations, etc., which can support guided inquiry and can be used constructively.

Social communicative tools include video conferencing, lab management systems, multimedia e-mailing and similar systems, which enable communicative processes between users. These tools, however, do not provide the means to organize knowledge and discussions. *Social constructive tools*, for example, document sharing, computer-supported intentional learning environments (CSILE) (Scardamalia and Bereiter, 1992), MindBridges (Chee, 1996), MUDs (Multi-User Domain) and MOOs (MUD Object-Oriented) (Looi, 1997) are computer-mediated environments that support the social constructivistic process. Although these environments may differ to some extent, they

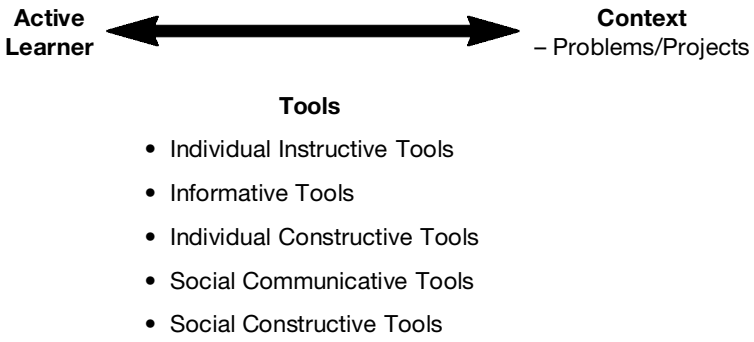

Figure 2 *Tools mediate between learners and context*

generically allow users to negotiate knowledge. These environments particularly make overt hidden meta-cognitive processes that would otherwise have remained implicit. Students would be able to generate knowledge and organize their ideas with the support of systems such as CSILE and MindBridges, which thread student discussions along thematic spaces. In addition, environments that support document sharing allow users to co-edit documents relevant to their work.

Surrounding the use of the five proposed tools, students or learners could be engaged in a problem-task context through which these tools are required for differing functions. For example, where the task context requires learners to search for information, searching through informative tools becomes prominent. When information has to be visualized, individual constructive tools such as spreadsheets could facilitate the interpretation process. When issues need to be discussed, learners could either use social communicative or constructive tools depending on the degree of interaction and dialogue. Instructive tools are used when one needs to be equipped with certain knowledge or skill for a task or sub-task. In other words, these tools function as mediators (tools to think with) for active learners to achieve the goal of 'solving' tasks or problems (see figure 2).

Conclusion

Ideally, we need a unified computer-based environment that allows us to integrate different kinds of tools easily. Distinctions among the five categories of tools may not be important as users can switch from one kind of tool to another within an integrated environment.

To reiterate, instead of regarding the different learning theories as discordant, we rather adopt the instructional approaches derived from each of the learning theories and situate them in the appropriate instructional context based on the learning objectives. We strongly advocate that teachers are 'pedagogical engineers' with the responsibility to plan a lesson(s) with the most relevant instructional approaches and technologies at his or her disposal.

References

Bateson, G (1972) *Steps to an ecology of mind*, Ballantine Books, New York.
Bateson, G (1979) *Mind and nature: A necessary unity*, Bantam Books, New York.
Barwise, J and Perry, J (1983) *Situations and attitudes*, MIT Press Cambridge, MA.
Bickhard, MH (1992) How does the environment affect the person? In Wineger, LT and Valsiner, J (eds) *Children's development in social context*, Lawrence Erlbaum Associates, Hillsdale, NJ.
Bredo, E (1994) Reconstructing educational psychology: situated cognition and Deweyan pragmatism, *Educational Psychologist*, 29, 1, 23–35.
Brown, J, Collins, A and Duguid, P (1989) Situated cognition and the culture of learning, *Educational Researcher*, 18, 1, 32–42.
Bruner, J (1990) *Acts of meaning*, Harvard University Press, Cambridge, MA.
Chee, YS (1996). MIND BRIDGES: A distributed, multimedia learning environment for collaborative knowledge building, *International Journal of Educational Telecommunications*, 2, 2/3, 137–153.
Clancey, W (1991) The frame of reference problem in the design of intelligent machines. In VanLehn, K (ed.) *Architectures for intelligence*, Lawrence Erlbaum Associates, Hillsdale, NJ.

Clancey, W (1992) *'Situated' means coordinating without deliberation*, McDonnel Foundation Conference, Santa Fe, NM.
Clancey, W and Roschelle, J (1991) Situated cognition: how representations are created and given meaning. Paper presented at the AERA Symposium, Implications of cognitive theories of how the nervous system functions for research and practice in education, April, Chicago.
Coulter, J (1991) Cognition: 'cognition' in an ethnomethodology mode. In Button, G (ed.) *Ethnomethodology and the human sciences*, Cambridge University Press, Cambridge, MA.
Dewey, J (1910/1981) The experimental theory of knowledge. In McDermott, JJ (ed.) *The philosophy of John Dewey*, University of Chicago Press, Chicago.
Dewey, J and Bentley, A (1949) *Knowing and the known*, Beacon Press, Boston.
Greeno, J (1991) Number sense as a situated knowing in a conceptual domain, *Journal for Research in Mathematics Education*, 22, 3, 170–218.
Lave, J (1988) *Cognition in practice: Mind, mathematics and culture in everyday life*, Cambridge University Press, Cambridge, MA.
Lave, J and Wenger, E (1991) *Situated learning: Legitimate peripheral participation*, Cambridge University Press, Cambridge.
Looi, CK (1997) Interactive Learning Environments for Promoting Inquiry Learning. Paper presented at the GCCCE conference 1997, 21–24 May, China.
Maturana, H and Varela, F (1987) *The tree of knowledge: The biological roots of knowledge*, Shambhala, Boston, MA.
Newman, D, Griffin, P and Cole, M (1989) *The construction zone: Working for cognitive change in schools*, Cambridge University Press, Cambridge.
Piaget, J (1960/1981) *The psychology of intelligence*, Littlefield, Adams & Co, New Jersey.
Prawat, RS (1996) Constructivism, modern and postmodern, *Educational Psychologist*, 31, 3/4, 215–225.
Reese, HW (1991) Contextualism and developmental psychology. In Reese, HW (ed.) *Advances in child development and behavior*, Academic Press, San Diego.
Rogoff, B and Lave, J (eds) (1984) *Everyday cognition: Its development in social contexts*, Harvard University Press, Cambridge, MA.
Roschelle, J (1989) *The construction of shared knowledge in collaborative problem solving*, Working Paper of the Institute for Research on Learning, University of California, Berkeley, CA.
Roschelle, J (1992). Learning by collaborating: convergent conceptual change, *The Journal of the Learning Sciences*, 2, 3, 235–276.
Rowe, HA (1991) Introduction: paradigm and context. In Rowe, HA (ed.) *Intelligence: Reconceptualization and measurement*, Lawrence Erlbaum Associates, Hillsdale, NJ.
Scardamalia, M and Bereiter, C (1992) Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media, *The Journal of the Learning Sciences*, 1, 1, 37–68.
Suchman, LA (1987) *Plans and situated actions: The problem of human-machine communication*, Cambridge University Press, Cambridge.
Skinner, BF (1974) *About behaviorism*, Penguin, London.
Still, A and Costall, A (eds) (1991) *Against cognitivism: Alternative foundations for cognitive psychology*, Harvester Wheatsheaf, London.
Tyler, S (1978) *The said and the unsaid: Mind, meaning, and culture*, Academic Press, New York.
Vygotsky, LS (1978) *Mind in society: The development of higher psychological processes*, Harvard University Press, Cambridge, MA.
Vygotsky, LS (1981) The genesis of higher mental functions. In Wertsch, JV (ed.) *The concept of activity in Soviet psychology*, M. Sharpe, White Plains, New York.
Winograd, G and Flores, F (1986) *Understanding computers and cognition*, Addison Wesley, New York.

Biographical Note

Dr David Hung is an Associate Professor at the National Institute of Education (Nanyang Technological University) and a sub-dean of e-learning at the University. His research interests lie mainly in the learning sciences and IT.

Address for correspondence

Dr. David Hung, National Institute of Education, Nanyang Technological University, 1 Nanyang Walk, Singaore, 637616; e-mail: wldhung@nie.edu.sg