Learning Theories and IT in Instruction

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After reading this chapter, the readers should be able to:

1. explain what each of the following terms mean :
   - behaviourism,
   - cognitivism,
   - constructivism, and
   - social constructivism,
2. give examples of how each theory can be applied in the school context,
3. make instructional decisions based on informed learning theories,
4. make decisions on how various technologies can be best integrated with instruction based on various learning theories.

Introduction

The aim of this chapter is to describe the dominant schools of thought of learning theories in relation to the use of technology in instruction. Four schools of thought are introduced: behaviourism, cognitivism, constructivism, and social constructivism. We use examples to explain how computer-mediated technologies can be integrated with teaching in relation to these theories. Instead of regarding the learning theories as discordant, we maintain that human cognition is complex and is beyond the limited explanation of any one of the learning theories. There is a role for every school of thought and instruction should always be designed based on the objectives and context of learning. Consequently, computer-mediated instructional technologies can also be incorporated into teaching accordingly based on the different contexts of learning and instruction.

In order not to distract readers from the main conception of each learning theory, we carefully refrain ourselves from too much jargon. Thus, the explanations below are written in relatively simple language for the practitioner-teacher. Moreover, we begin by introducing each school of thought by first providing an example, from which we gradually introduce the main tenets of that particular theory. We hope that this way of presentation will situate these theories more closely to their applications to teaching.

A behaviourist example

Suppose our instructional goal is for students to memorize a particular multiplication table. As a concrete example, suppose the instructional objective is: given two numbers (no greater than 10), students will be able to recall the product of the two numbers without hesitation (less than 1 second). Note that we are not talking about teaching the concept of multiplication *per se*. Our example focuses on how students memorize the multiplication table. We will use this same instructional scenario to illustrate how different learning theories inform our practice of teaching and the use of IT.

Thus, how would a behaviourist teacher design the learning activity? One possible approach is that the teacher gives to the students printouts of the multiplication table. The lesson could be designed in such a way as to move students systematically from the easier to the more difficult tasks. For example, first focus on the 1's and 10's, then the 5's or 2's, and subsequently the others. Students will probably be tested on the multiplication table everyday until they master them. In addition, a computer based learning program for drill and practice could be used. The drill and practice could also be "disguised" under a game format (e.g., a mission to save the earth) so that students are motivated to practice more.

Some rewards systems could be set up to encourage students to perform well on tests. The student's mastery level could be closely monitored by the daily tests we commonly administer. The weaker students could receive extra help by doing more computer-based drill and practice. The advanced students will be able to play more games (more practices) or to move on to the next topic sooner.

Behaviourism

The above example typifies the behaviourist approach to teaching, which is derived from the stimulus and response theory of B.F. Skinner (1974). Behaviorists believe that a learner's response to a stimulus is strengthened by reinforcement. The assumption is that if students respond to stimulus "correctly," they have learned. Otherwise, more stimuli should be provided until the "correct" behaviour is observed. In the above example, the stimuli are the printouts of the multiplication table, the tests, and the drill and practice (or games). Students are to respond to the stimuli by reciting the product of any two numbers. The success of learning is observed by those explicit behaviours (e.g. reciting the products, performance on tests).

Thus, the primary tasks of the teacher are to provide stimulus (practice) and observe if students respond according to the desired outcomes, so that the appropriate reinforcement can be administered. The rewards system is a kind of reinforcement to encourage students to perform well. The computer-based drill and practice 'disguised' as a game is another way of reinforcing students in order to be engaged in more practices.

The behaviourist approach is most effective when there are absolutely no rules to follow or rely on or when the purpose is to memorise the rules and the only way to learning is through rote memorization**.** Examples of such situations include memorizing the number sequences, recalling names of objects, recognising alphabets, etc. Usually, very little higher order thinking (e.g., compare and contrast, synthesis, problem-solving) from the student is required.

A cognitivist example

A cognitivist teacher would start the same multiplication table lesson differently. The teacher will always identify patterns, rules or principles first. From his/her own expert experience, the teacher will teach students the most effective/efficient way of memorizing the table. These may include rules and patterns that help the students to memorize the multiplication table better. In order to teach the multiplication table, the teacher would probably point to the student different patterns of the table. These patterns will help students to come up with the products in a much more meaningful way compared with pure memorization.

For example, the teacher could begin the lesson by directing students to observe the inter-changeability or associative relationship of two numbers (e.g., 2*3 = 3* 2) in multiplication. This would immediately reduce the number of pairs that students have to memorize. The teacher could further point out the patterns of the 9's by the sum of the two digits (e.g., 9*6 = 54; 5+4 = 9; 9*7 = 36; 3+6 = 9). A computer tutorial program teaching these various patterns could be used for students to learn these "expert knowledge." Every time a pattern is introduced, students will be asked to answer questions related to that pattern until they fully understand what that pattern means and how to apply that pattern to their learning of the multiplication table. An intelligent tutoring system could be used to detect student misunderstandings and to model how the teacher would help students learn and apply these rules.

Cognitivism

Cognitivists contend that the mind is governed by rules and principles just as how the computer is governed by software programs. They focus on functions of memory and how the mind encodes information. The Information Processing theory proposed by Atkinson and Shiffrin (1968) is an example of cognitive psychology that focuses on the memory and storage processes that make learning possible. Under this paradigm, a learner's mind is perceived as an information processor with short-term and long-term memories, including a working memory. Proponents of information processing theories differ from the behaviorists' view that stimulus-response learning alone could form the basis for higher order learning. Instead, they are more concerned with the internal processes that take place during learning. Figure 1 is a typical model of the information processing model which is similar to how a computer's central processing unit would function. Inputs come into a person and via a sensory register, these inputs are processed by a working memory (similar to RAM) and subsequently stored into long-term memory (the hard disk).

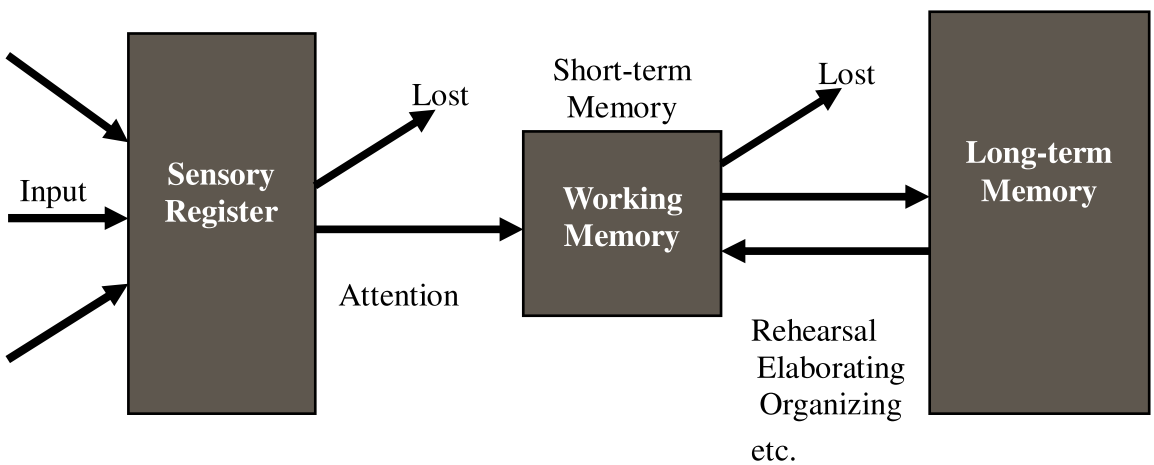

Figure 1. The Information Processing Model

A central function of the mind is to process the information, sort them in a meaningful way. The process is determined by the rules and principles employed. Learning is then perceived as appropriating these rules and principles and being able to apply (or process information) according to these rules. As a result of this paradigm, efforts have been devoted to study how experts process information. By analysing the way experts think and by teaching students these expert ways of thinking, cognitivists hope to instruct students in order to emulate expert thinking, and to develop the students' expertise is a particular domain of knowledge.

In our example above, the teacher is perceived as an expert in memorizing the multiplication table. It is the teacher's responsibility to analyse how he/she approaches the learning and to teach the students the "right" way of thinking. Students are to first learn the rules (e.g. a*b=b*a) and then to apply to as many incidents as possible (e.g., 2*3=3*2, 7*5=5*7, etc).

The cognitivistic approach is best employed when the domain of knowledge is too complex for students to explore and to grapple with independently. The interplay between students' current level of understanding and the potential level of understanding with assistance from the more capable ones is an important factor for the teacher to decide whether or not to employ this approach. For example, abstract concepts such as prime numbers will probably have to be taught through the cognitivistic method before other approaches can be incorporated. That is, the teacher has to start the lesson by introducing the concepts, rules and principles such as the definition and significance of prime numbers. Students are to come up with examples of prime numbers after being taught the definition in order to exhibit their understanding. On the other hand if the domain of knowledge is not too complex and if, with a little bit of effort, students are able to discover the patterns or rules, the teacher could consider using the constructivist approach, which is elaborated in the following section.

A constructivist example

A constructivist teacher would probably not start with presenting patterns or rules of the multiplication table. Rather, he/she expects students to find and discover these rules by themselves. The teacher will prepare ample resources and appropriate tools for students to explore and play with. One possible approach is to give students printouts of the multiplication table. The activity is then for students to discover patterns of the table by themselves. The teacher will guide students by asking questions. For example, the teacher may ask what kind of patterns students would find for the 9's (see earlier cognitivist example). Once the student discovers the patterns, it will be very difficult for them to forget. If students cannot find the patterns, the teacher may further provide hints to the student to pay attention to the sum of the two digits. These questions serve as scaffolds at initial stages and will eventually be removed once students have discovered the patterns. The computer can be employed as a cognitive tool for students to play and experiment with ideas. These may include visualization tools for students to see trends of the data, concept map tools for students to see associations of ideas, etc. Information tools such as the Internet can also be used by the students to gain access to raw and unprocessed information (e.g., data of the stock market, or the weather temperatures) for further exploration.

Constructivism

The constructivist theory, as advocated by Piaget (1960/1981) and Bruner (1990), stresses that whatever gets into the mind has to be constructed by the individuals through knowledge discovery. Its emphasis is on how a student constructs knowledge. For example, when shown the same image, e.g., the duck-rabbit, some individuals may interpret the picture differently.

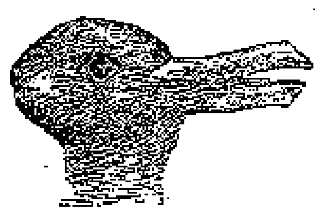

Figure 2. A picture that can be interpreted as a duck or a rabbit.

The same stimulus enters into the eyes of the individual, yet the mind interprets or constructs the image differently. Learning is seen taking place if a student can construct his/her own knowledge and apply or generalize its meanings to new situations. Various learning strategies are suggested. For example, students may be engaged in collecting unorganised information, from which they induce concepts and principles. Students then apply the newly constructed concepts and principles to new situations. Through this experimentation process, students validate, modify, and generalize the acquired concepts and principles.

In the above multiplication table example, students are encouraged to find patterns that they hypothesize. Students are then required to test the pattern by applying it to the table. If the pattern fits, students will be able to use the pattern to help them memorise the table. If it does not fit, students would then have to come up with alternative hypothesis and continue the enquiry cycle. To the extreme constructivists (individuals who hold a radical view of constructivism), expert knowledge is de-emphasised. Everyone is entitled to constructing knowledge according to his/her own experience. There is no one right way of seeing or learning. Every way is correct in its own right as long as the desired learning outcome remains. One main argument for the constructivist approach to learning is that once personal knowledge is constructed, as opposed to being told (as of the behaviourist and cognitivist approaches) it is meaningful to the individual and it is not easily lost.

The constructivist approach is best employed when the new knowledge to be learned is not too much beyond the student's current level of capability. With a little bit of effort, most students should be able to discover meanings of the topic. The teacher is not to directly teach the rules or patterns. Rather, his/her role is to facilitate students' discovery and to ask questions in order to steer students' directions in exploration.

A social constructivist example

How would a social constructivistic teacher conduct the lesson of the multiplication table? This is a difficult example to demonstrate. Basically, a social constructivistic teacher will not include “memorizing” the table as the only intended learning outcome. The learning of the table will have to be situated in a real-life context. The teacher would probably set up a “mini-mart” in the class and ask students to act as customers and cashers. Through the real life business transactions, students do not just learn to memorize the multiplication table, but also the concept of multiplication, sum, etc.

For the sake of making our example clearer as a practical approach to social constructivism, it is conceivable that the social constructivistic teacher sets up groups of students to explore the patterns of the multiplication table. Students discuss within their own groups what patterns they have found. The learning activity of the class could be a competition for students to come up with the best way of recognizing the patterns. Through the discussion, students would try to present the “best” way to memorize and to justify why their own discovery is the best. Through the discussion, students are exposed to different perspectives and how others would analyse the multiplication table. A communication tool such as the discussion forum can be used to facilitate the discussion. Any collaboration-enabled constructive tools such as document conferencing and electronic whiteboard are very appropriate for the supporting social-constructivist type of learning approach.

Social constructivism

The theoretical underpinnings of social constructivism are similar to constructivism, except that how one constructs knowledge or meanings are also bound by one’s social cultural influence or bearings. For example, in the duck-rabbit image, an individual may construct an imagery of a duck (and not a rabbit) because he or she has been exposed to farm life, whereas a rabbit may not be commonplace in one's upbringing. Such views are also rooted to recent notions of situated cognition, where social, historical, and cultural contexts are intricately linked to the interpretations of meanings and knowledge (Brown, Collins & Duguid, 1989). Geertz (1983) also points out that many things we take as 'just common sense,' are in fact matters of cultural influence. Each person living in his/her own society has developed a point of view that is in line with the mainstream perspectives of that cultural society. In addition, social constructivism sees language as a way for social coordination and adaptation (Dewey, 1958; Hayakawa & Hayakawa, 1976). Through language, members of a learning community learn to interpret the world in similar ways; they develop similar views about external reality. That is, human learning is 'human languaging,' the exchange of conversation and dialogue (Maturana & Varela, 1987). Learning occurs when students socially build, share, and agree upon knowledge. By exchanging and sharing notions with others, knowledge is formed and thinking occurs.

The social constructivist approach is best used when there are no absolute right answers to a certain problem and when different perspectives are valued. For example, what is the best way to memorize the multiplication table, what constitutes good writing, how to explain a certain phenomenon, and how to effectively solve a particular ill-structured or real-life problem, etc.

Summary of the four theories

To reiterate, behaviourism focuses on observable behaviours as the basis for learning. Cognitivism emphasises expert knowledge and the direct teaching of rules and principles. Constructivism focuses on the construction of knowledge by individuals whereas social constructivism elevates the importance of the historical and social context through which the knowledge was constructed. Table 1 summarizes the four learning theories with short descriptions of their general orientations.

Learning theory	General orientations
Behaviourism	Stimulus and response Students remember and respond. (Change in overt behaviour due to conditioning) Teachers present and provide for practice and feedback
Cognitivism	Information transmission and processing Students remember strategies, rules, and patterns Teachers plan for cognitive learning strategies
Constructivism	Personal discovery of knowledge Students discover relationships between concepts Teachers provide instructional context and guide students to discover
Social Constructivism	Learning is a social construction, mediated by different perspectives Through authentic projects, students discuss, negotiate and discover meanings Teachers provide for facilitation and scaffolds among the students

Table 1. Summary of Theories of Learning

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 favor 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 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 has still 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 contradiction for the use of instructional 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 engaged in constructivist and social constructivist activities. Students can extend on knowledge gained and further experience the relationship of concepts as they construct meanings among themselves. The issue, then, is how best can students learn from the various instructional approaches adopted in the classroom, and the balance accorded to each approach.

The recent directions in computer-mediated tools and instructional technologies have been from individual centered 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 which enable learners 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 2 illustrates the kinds of computer-mediated tools with the respective learning theory.

Behavorism	Variety of drill and practice computer-based learning software	Individual Instructive Tools E.g., CBLs that drill students on multiplication and addition
Cognitivism	Tutorials and Information databases	Informative Tools, Computer-based Tutorial E.g., Encyclopedia and Internet resources
Constructivism	Individual generic purpose tools	Individual Constructive Tools E.g., Excel, Word, and PowerPoint, Simulations, Hypertext and hypermedia, Organizational tools
Social constructivism	Collaborative generic environments	Social Communicative / Constructive Tools E.g., Emails, Bulletin boards, Knowledge co-construction/exchange forums, Computer-mediated collaborative problem solving environments

Table 2. Computer-mediated tools and learning theories

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: (a) Individual instructive tools, (b) Informational tools, (c) Individual constructive tools, (d) Social communicative tools, and (e) Social constructive tools (Figure

3). Examples of *individual instructive tools* include traditional tutorial and drill and practice types of programs. They are typically designed to be used by individuals and are good tools for supporting basic information and knowledge such as the multiplication table. *Informational tools* provide necessary materials and resources for students to construct their knowledge. Examples of such technologies include encyclopedias 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 validity of their knowledge negotiations. *Individual constructive tools* are multimedia authoring tools, spreadsheets, word processors, simulations, or the like, which can support guided inquiry and can be used constructively.

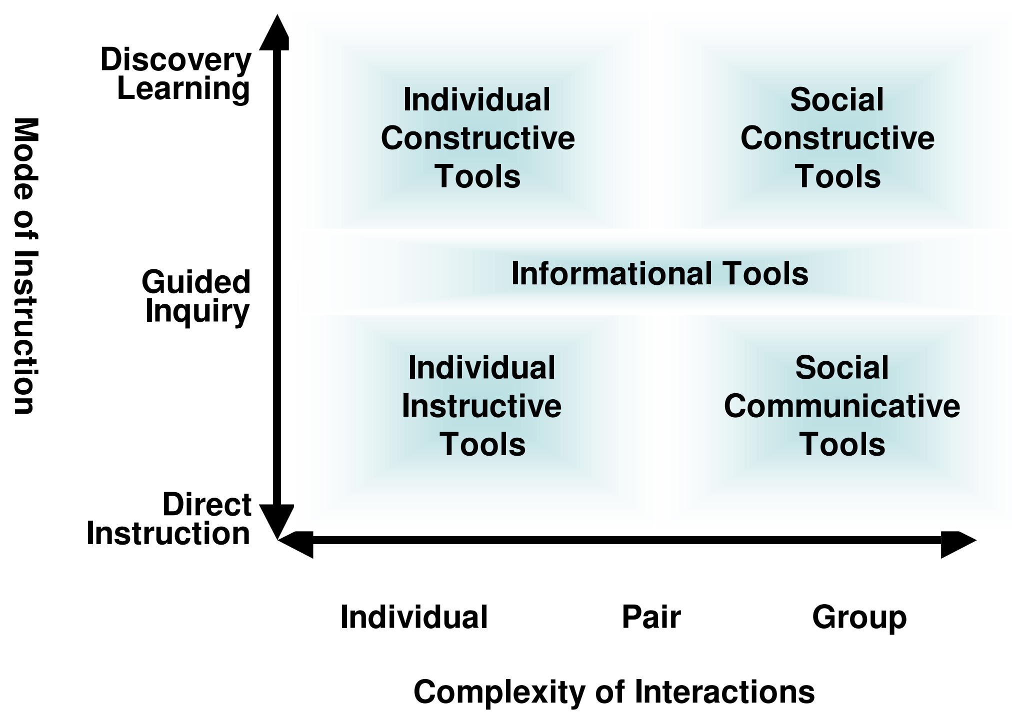

Figure 3. The five types of instructional technology

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 et al., 1989), MUDs (Multi-User Domain) and MOOs (MUD Object-Oriented) (Looi, 1997) are computer-mediated environments which support the social constructivistic process. Although these environments may differ to some extent, they generally allow users to negotiate knowledge. These environments particularly make overt hidden metacognitive 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, 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 use either social communicative or constructive tools depending on the degree of interaction and dialog. 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.

Conclusion

With the recent emphasis on pedagogies in IT integration, we reckon that the framework of IT tools as proposed above fits into our perception of how and when different learning theories can be adopted. Although we are generally moving towards a learner-centred paradigm, we are suggesting that there is a role in human cognition and behaviour for behaviourist and cognitivist pedagogies. We need to distinguish between human and learning theories of the mind from instructional pedagogies and strategies. Having a model of cognition to be relatively constructivist does not preclude the use of instructive methods at appropriate junctures of knowledge construction. The IT tools framework as described in this Chapter supports the different learning paradigms and each kind of tool use should be situated in its appropriate context and learning situation.

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