# Theoretical and Epistemological Foundations of Integrating Digital Technologies in Education in the Second Half of the 20th Century

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**Abstract**: This chapter provides an overview of theoretical and pedagogical perspectives related to the integration of digital technologies in the second half of the 20$^{th}$ century. It evaluates dominant discourses, epistemological frameworks and theories of learning that have been influencing the deployment of new technologies into schools and their integration in learning and teaching. The four epistemological models examined in this chapter are behaviourism, cognitivism, constructivism and sociological and organisational interpretations of integrating new technologies into teaching and learning. The analysis focuses on the nature of knowledge, the nature of learning, the learning environment, the role of technology in student learning, the changing roles of teachers and learners, and the social and organisational consequences of technology integration that play a significant role in understanding the key determinants of managing pedagogical transformation and educational change.

**Keywords**: pedagogical perspectives, epistemological models, role of technology

## 1. Introduction

It has become apparent that dominant learning theories, pedagogical perspectives and epistemological models have a significant influence on the nature of integrating emerging technologies into learning and teaching. This chapter offers a historical perspective on four major schools of thought, prevalent in the second half of the 20th century, which influenced the uptake of digital technologies in education.

The impact of behaviourism, cognitivism and constructivism alongside with sociological and organisational interpretations of integrating new technologies is examined in relation to the learner, teacher and the process of learning. It is anticipated that the chapter will provide the readers of this book with an insight into some of the key thinking that provided a backdrop to a global pedagogical transformation and a cultural shift in 21$^{st}$ century education.

## 2. Behaviourism and the Technology of Instruction

Behaviourism is a school of psychology that was influenced by pragmatism, functionalism and experimental animal psychology (Todd & Morris, 1995). Critics of behaviourism associated it with evolutionary epistemology that assumed that "*knowledge is entirely a product of our evolutionary history*" (Staddon, 2004, p. 234). Behaviourist approaches to student learning have dominated education in the second half of the 20th century. Their influence on teaching and learning can still be observed in educational institutions around the world. These approaches rest on the shoulders of giants such as Pavlov, Watson, Thorndike, Skinner, Keller, Binet and Terman, who made significant contributions to understanding human behaviour. The basic assumption of behaviourist approaches to learning is that learning results in a change in behaviour that can be observed and measured (Skinner, 1974; Thorndike & Hagen, 1969). Change in behaviour must be evaluated and assessed by carefully designed means of psychometrics, such as direct observation and tests. The goal of the learning process is strongly linked to learning outcomes and assessment of learning. Learning is a response to external stimuli, through classical conditioning (Pavlov, 1927) or operant conditioning (Skinner, 1984; Thorndike, 2000), and is strongly influenced by reinforcement, which comes in a form of reward/punishment or consequences (Skinner, 2005). However, behaviourist interpretations of learning and learners are often oversimplified and taken out of context in contemporary literature (Burton, Moore, & Magliaro, 2004; Catania & Harnad, 1988; Gaynor, 2004). Gaynor (2004) argued that many authors over-generalise and are making exaggerated claims. Examples of such approaches are linking radical behaviourism to logical positivism; and the myth 'tabula rasa' (blank slate) which is incompatible with Skinner's view of the learner who, in his own words, "*does not passively absorb knowledge from the world around him, but must play an active role*" (Skinner, 1968, p.5).

Behaviourist applications of instructional technology are based around basic principles related to the role of the learner, the nature of learning, and the generality of learning principles (Burton et al., 2004). According to Burton et al., learning occurs "*by doing, experiencing and engaging in trial and error*" (p. 9). The emphasis is on the active responding of the learner who "must be engaged in the behaviour in order to learn and to validate that learning has occurred" (p. 9). As discussed above the nature of learning is defined as "*a change of behaviour due to experience*" (p. 9). Central to learning is content. The learning material, based around the content, is delivered in contingencies or sequences that are broken down into small steps. The steps are taking the learner from simple to more complex tasks and reward him/her upon successful completion. Behaviourists claim that learning follows universal laws and "*the basic processes that promote or inhibit learning are universal to all organisms*" (Burton et al., 2004, p. 9).

The implications of behaviourist principles for learning environments have been summarised by Wilson (2000, p. 62) and are presented in the Table 1.

| | |
|---|---|
| Learn by doing | People learn best by actively engaging in tasks. This is commonly called practice or learning by doing. |
| Taxonomies | Learning outcomes can be differentiated in their type and complexity – for example, simple S-R bonds, concept classification, and rule- |

| | |
|---|---|
| | following. Such learning outcomes are compiled into classification schemes called learning taxonomies, which in turn guide selection of learning objectives and instructional strategies. |
| Conditions of learning | For each type of learning, conditions can be identified that lead to effective learning. Identifying optimal conditions of learning forms the basis of prescriptive instructional theory using the formula: to accomplish X learning outcome, apply or arrange for Y conditions. |
| Behavioural objectives | Instruction should be based on clear, behaviourally specified learning objectives. Explicit formulation of objectives helps link instructional goals with evaluation and assessment, leading to increased accountability. |
| Focus on results | Teachers and schools should be accountable for their students' learning. Measurable behaviours are the best index of true learning outcomes and should be used to gauge instructional effectiveness. |
| Alignment | Good instruction exhibits an alignment or consistency between learning objectives, instructional strategies, and strategies used to assess student learning. Misalignment of these components results in inadequate or unfair instruction. |
| Task decomposition | People learn best when complex tasks are broken down into smaller, more manageable tasks and mastered separately. |
| Prerequisites | Subtasks often become prerequisites to larger tasks. That is, students learn the larger task more easily when they have first mastered the subtasks. This leads to parts-to- whole instructional sequence. |
| Small successes | Subtasks have another advantage: They allow students to succeed. Succeeding at tasks is reinforcing, resulting in greater motivation to continue. |
| Response-sensitive feedback | People learn best when they know the correctness of their efforts. When performance is not correct, specific information should be conveyed concerning what was wrong and how to improve the next time. |
| Science of instruction | Educators need to be precise and systematic in their thinking, their teaching, and their evaluation of students. Education can be treated as an applied science or technology, where through empirical inquiry, principles are discovered and applied. |
| Performance support | People need support as they perform their jobs, through the use of job aids, help systems, and feedback and incentive systems. On-the-job, just-in-time training and support works best. In general, the closer the training is to job conditions, the more effective learning will be. |
| Direct instruction | Giving clear directions, well prepared presentations, suitable examples, and opportunities for practice and transfer, are proven methods that result in substantial student learning. |
| Pretesting, diagnostics, and placement | Students should not all be forced to endure the same instructional program. Instead, instruction should branch into alternative treatments according to prior skills, motivation, and other critical variables. |
| Transfer | In order to be able to transfer a skill from one task to another, students need practice doing it. If students never have opportunities to practice transferring their skills, they should not be expected to be able to perform on demand in test situations. |

**Table 1**: Behaviourist insights for designing learning environments (Source: Wilson (2000, p. 62)

According to Gillani (2003), the principles of behaviourist theories of learning have been successfully applied to instructional designs integrating technology in multimedia and e-learning environments. Such instructional designs are: Carroll's Mastery Learning; Skinner's Programmed Instruction; Personalised System of Instruction; Teaching to the Test; and the Direct Instruction Model. These applications of digital technologies utilise instructional approaches to learning such as tutorials and drill and practice tasks that are often criticised by contemporary literature on ICT. According to Yelland (2007), such applications of new technologies do not use their potential to engage students in new learning experiences, and in Bowers' (1998) opinion they result in decontextualized forms of knowledge.

## 3. Cognitivism and New Technologies

Cognitivism emerged in the 1950s as an alternative to behaviourist conceptions of learning. It was a response to the growing need for understanding the mental processes in human beings, such as perception, memory, attention and thinking. Cognitivism in education was influenced by new developments in cognitive sciences such as psychology, mathematics, cybernetics and linguistics (Nahalka, 1997). Theories of learning based on cognitive developmental research focused on mental processes by which knowledge was acquired and retrieved in order to solve problems (Gillani, 2003).

Departing from behaviourist explanations of learning, cognitivists brought the mind to the centre of psychology (Wilson, 2000). However, like their behaviourist counterparts, cognitivists also emphasised the importance of empirical research as a legitimate pathway in arriving at new understandings. According to Wilson, cognitive researchers used methods such as reaction-time experiments, eye-movement studies and think-aloud protocols to develop "*computational models of the human mind that filled many of the gaps left by behaviourism*" (p. 63).

The following key ideas and theoretical stances have shaped the development of cognitive theories of learning:

- Tolman's pioneering work on purposive behaviour and cognitive maps (Tolman, 1967; Tolman, 1990),
- Piaget's theory of cognitive development (Piaget, 1952),
- Vygotsky's Marxist psychology and social constructivism (Vygotsky, 1967, 1986),
- Blooms's Taxonomy of Educational Objectives (Bloom, 1956),
- Ausubel's theory of Advance Organizers (Ausubel, 1960),
- Gagne's Nine Events of Instruction (Gagné, 1985),
- Bandura's social cognitive theory (Bandura, 1989), and
- Bruner's views on education, and his theory on categorisation (Bruner, 1986; Bruner, 1990).

There are two main schools of cognitivist interpretations of learning that influenced the use of digital technologies in education. These are symbolic cognition or Information Processing Theory, and situated cognition.

Symbolic cognition or Information Processing Theory (IPT) has shaped the early cognitivist theory of learning environments and instructional design. According to Lewis' explanation in the MIT Encyclopaedia of Cognitive Sciences (Lewis, 1999), symbolic models of human cognition are perceived as computational processes. These cognitive models are made up of a set of procedures that enable the performance of specific tasks, such as memory tasks, language comprehension and problem-solving. Lewis (1999) argued that scientific explanations of these models come from cognitive psychology and artificial intelligence, which provide the theoretical foundations of symbolic cognition or IPT.

IPT had a significant influence on instructional design towards the end of the 20th century. It was anticipated that artificial intelligence and expert systems would replace the teacher. Distance learning and early online learning environments held hopes for automatising the learning process. Situated cognition viewed children's growth in knowledge "*as a series of stages from concrete to abstract forms of reasoning or as accumulation of procedural and declarative knowledge about the world*" Wilson (2000, p. 64). Wilson argued that children "*make sense of their worlds by reference to schemas, mental models, and other complex memory structures*" (p. 64). In his opinion "*differences between encountered experience and schemas can prompt further inquiry and reflection to resolve the conflict. Instruction should help learners assimilate and accommodate new information into existing schemas and cognitive structures*" (p. 64).

Situated cognition is the other cognitive theory of learning. According to Wilson (2000), situated cognition departs from rigid models of IPT and symbolic computation. It focuses on "*conscious reasoning and thought*" (p. 65) and the context of situated action. Situated cognition is often associated with social constructivism (Wilson, 2000, p. 65).

Jonassen, Davidson, Collins, Campbell, & Haag (1995) argued that while cognitivism represents a paradigm shift from behaviourism, symbolic learning and situated learning represented two distinct schools of thought. According to Jonassen at al. (1995), proponents of symbolic reasoning represented the traditional objectivist paradigm. They perceived the world as a structure that can be "*modelled and mapped onto the learner, and that the goal of the learner was to 'mirror' reality as interpreted by the instructor*" (p. 10). Because knowledge was thought to be external to the knower it was believed that it could be transmitted from one person to another (Jonassen et.al, 1995, pp. 10-11).

According to Jonassen et al. (1995), unlike symbolic reasoning, situated learning rests on different epistemological assumptions about the learner and learning. This is how they describe this new paradigm:

> *Constructivism (which provides the psychological/philosophical foundation for situated learning) begins with a different set of assumptions about learning. Constructivists believe that our personal world is constructed in our minds and that these personal constructions define our personal realities. The mind is the instrument of thinking which interprets events, objects and perspectives rather than seeking to remember and comprehend an objective knowledge. The mind filters input from the world in the process of making those interpretations. The important epistemological assumption of constructivism is that knowledge is a function of how the*

*individual creates meaning from his or her experiences; it is not a function of what someone else says is true. Each of us conceives of external reality somewhat differently, based upon our unique set of experiences with the world and our beliefs about them.* (Jonassen et.al, 1995, p. 11)

The authors argued that constructivist educators strive to create learning environments that require active participation of the learner with the learning environment in order to create a personal view of the world. In their opinion, the purpose of this new theory of learning is not to "*predict the outcomes of instructional interventions*" (p. 10) but as Bruner (1990) said to encourage learners to discover new meanings through their encounters with the world. Jonassen et al. (1995) maintained that this new learning theory "*transcended the behaviourism–cognitivism dialectic and entered a new era of theorizing*" (p. 9). The Jonassen et al.'s summary of the features of these two distinctive cognitive theories is presented in the Table 2.

| *Symbolic Reasoning* | | *Situated Learning* |
|---|---|---|
| | Knowledge | |
| Objective | | Subjective |
| Independent | | Contextualized |
| Stable | | Relative |
| Applied | | Situated in Action |
| Fixed | | Fluid |
| | Learning | |
| Objectivist | | Constructivist |
| Product-oriented | | Process-Oriented |
| Abstract | | Authentic |
| Symbolic | | Experiential |
| | Memory | |
| Stored Representations | | Connections , potentials |
| | Knowledge | |
| Functionally equivalent to | representation | Embedded in experience |
| the real world | | Personally constructed |
| Replication of expert | | Personalized |
| Symbolic, generalized | | |
| | Instruction | |
| Top down | | Bottom up |
| Deductive | | Inductive |
| Application of Symbols | | Apprenticeship |
| | Computational | |
| Symbolic reasoning | model | Connectionist |
| Production rule | | Neural network |
| Symbol manipulations | | Probabilistic, embedded |

**Table 2:** Contrasting assumptions of paradigms (Jonassen et al. (1995, p. 10))

The above theoretical framework revealed a powerful shift in the way the knowledge-learner-teacher-technology relationships were conceptualised. Similarly to other transitions in pedagogical thought, this shift reflected the hallmarks of fresh and emerging schools of thought of the second half of the 20th century in social and natural sciences, such as postmodernism (Foucault, 2002; Giroux, 1992; Heidegger, 1977; Wittgenstein, 1953) and constructivism (Glasersfeld, 1995b; Piaget, 1970;

Vygotsky, 1978, 1986); the theory of probability (Kolmogorov, 1956), neural networks and Fuzzy Logic (Kosko, 1993; Zadeh, 1973).

Cognitive theories of learning have made a significant contribution to the design and development of constructivist learning environments integrating new technologies, especially in the fields of inquiry training, hypermedia, discovery learning and simulation (Gillani, 2003). According to Gillani, cognitivists viewed technology as a tool for creating instructional materials and learning environments that allow children to "*construct, test, and refine their own cognitive representations of the world*" (p. 64).

In his book on Learning Theories and the design of E-learning environments (Gillani, 2003), Gillani emphasised the contribution of Seymour Papert, Robert Davies, Duffy and Jonassen. Papert, built on Piaget's work (with whom he worked for a number of years), and developed the LOGO project, a "*computer-based discovery learning approach*" (2003, p. 62), that enabled children to construct their own knowledge. He also created Microworlds, a learning environment which allows young children, to become designers, constructors and explorers. Robert Davies was another prominent figure in using technology to design constructivist learning environments. Davies made a significant contribution to the development of multimedia and hypermedia through his Plato project that combined text, graphics, animation and audio and the development of interactive textbooks. Gillani (2003) argued that the Plato project inspired the development of multimedia authoring software such as Hyperstudio, Director, and Flash that enable teachers to create their own interactive, multimedia teaching material. Duffy and Jonassen's (1992) application of constructivist ideas to learning with new technologies provided an alternative framework to early computational views of cognition. According to Kerr (2004), this new epistemological framework redefined the role of the learner and interpretations of how knowledge is constructed.

## 4. Moving Forward on the Constructivist Continuum with ICT

Constructivism has its foundations in philosophy, psychology, cybernetics (Winn, 2004), and in cultural history (Glasersfeld, 1989). The philosophical roots of constructivist thought relate back to Kant's idea of the human cognitive apparatus, Kuhn's analysis of scientific revolutions and paradigms, Dewey's conceptualisations of knowledge and knowing, Piaget's cognitive theories of personal development, and Vygotsky's interpretations of the impact of the social-cultural environment on learning.

Constructivism is an umbrella term for several schools of thought, such as social constructivism, radical constructivism and critical constructivism, that question traditional notions of knowledge, knowing and knowledge production (Glasersfeld, 1989). According to von Glasersfeld (1995a), constructivism emerged "*out of a profound dissatisfaction with theories of knowledge in the tradition of Western philosophy*" (p. 6). This Western philosophical tradition is often referred to as objectivism. Kincheloe (2005) argued that "*objectivism is grounded on the rationalist* *myth of cold reason*" (p. 13) and exists as a "*scientific discovery of external reality*" (p. 13).

The following constructivist ideas relevant to new learning with ICT will be reviewed in this section: Jonassen's model of constructivist learning environments, and Vygotsky's theory of Zone of Proximal Development (ZPD) in relation to learning with new technologies. These ideas provide the theoretical foundations for creating meaningful and relevant educational experiences for both students and teachers that will prepare them for the challenges and uncertainties of living, learning and working in a digital world.

Constructivist theories of learning are based on the premises that learning is both individually and socially constructed by learners through their interactions with the world (Jonassen, 1999b) Constructivist learning environments rest on these assumptions and represent an "*antidote to reproductive learning*" (Jonassen, 1999b, p. 1). Such learning environments engage learners in active, manipulative, intentional, complex, authentic, collaborative and conversational and reflective learning activities (Jonassen, 1999b, 2001) In Jonassen's opinion constructivist learning environments support the adoption of problem-based, project-based, case-based, and issue-based learning. In his opinion, new technologies, especially web-based resources provide valuable tools and resources for scaffolding such learning experiences. His model of constructivist learning environments (Jonassen, 2001) shown in Figure 1, reflect these principles.

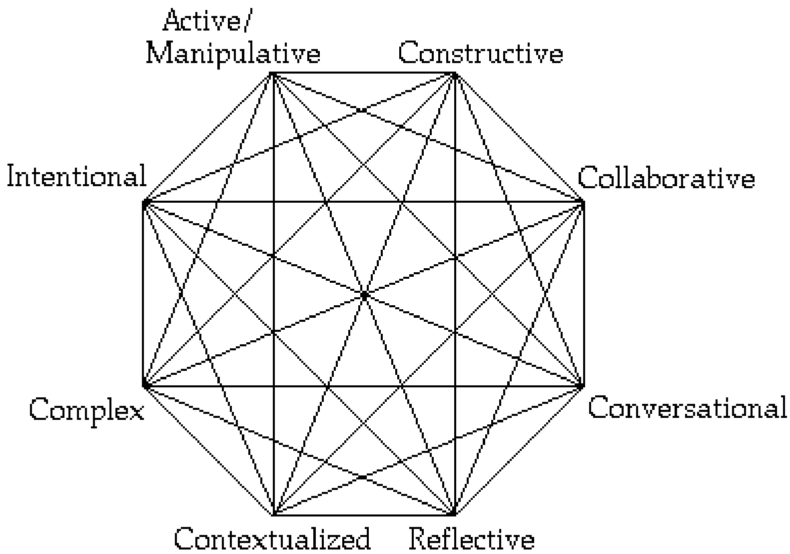


**Figure 1:** Jonassen's model of constructivist learning environments (2001)

Constructivist learning is authentic, that is, it makes meaning from practice related to learners' personal contexts, and is based on scaffolding and social interaction. Yet most learning in schools occurs in learning environments that are abstract and decontextualised (Brown, Collins, & Duguid, 1989; Kolb, 2000; Polly, 2003).

One of the pioneers of recognising the implications of the social context for learning was Lev Vygotsky. He identified two levels of cognitive development: the actual developmental level, and the Zone of Proximal Development (ZPD) (Vygotsky, 1978). Learners actual developmental level reflects their cognitive maturity related to the "*development of mental functions that has been established as a result of certain already completed mental cycles*" (Vygotsky, 1978, p. 85). Through social interaction, such as scaffolding or collaboration in multi-age settings, the boundaries of the actual developmental level related to problem-solving can be extended. In such situations learners move into a new zone of cognitive maturity, the ZPD, which, according to Vygostky, is the "distance between the actual developmental level as determined by individual problem-solving and the level of potential development as determined through problem-solving through adult guidance or in collaboration with more capable peers" (p. 86). Vygotsky's theory is highly relevant for learning in the information age (Holmes et al., 2001), with research studies (Masters & Yelland, 2002; Salomon, Globerson, & Guterman, 1989; Siraj-Blatchford & Siraj-Blatchford, 2006) showing that new technologies are tools and resources that provide opportunities for higher-order thinking, inquiry and problem-solving under guidance or in collaborative settings.

## 5. Sociological and Organisational Interpretations of Integrating ICT in Teaching and Learning

Sociological and organisational interpretations of new technologies have been often associated with economic progress and efficiency in the knowledge society. It has been assumed, that new technologies will bring to education "*efficiency, order and productivity*" (Kerr, 2004, p. 113), and facilitate educational change, including the transformation of existing structures and organisational forms (Orlikowski & Yates, 2006) as well as social practices, which according to Giddens (1984) represent individual or collective human action, and are "*performed for social reasons*" (Tuomela, 2002, p. 78).

Kerr (2004) argued that this "*mechanistic enthusiasm*" (p. 113) expected new technologies to bring solutions to all educational problems and challenges, that would with the implementation of the 'right program' run schools and classrooms smoothly. Kerr observed a dialectic relationship between educational organisations and new technologies. He said that while the way technologies are integrated into schools depends on the "*patterns of organization*" (p. 119), at the same time new technologies affect the life of organisations and often "*translate over time into unexpected organizational and social consequences*" (p. 119).

To understand the human, social, and organisational consequences of technology integration into social practices it is important to look at the ontological and epistemological foundations of contemporary theoretical explanations in social theory and organisational science. Orlikovski and Robey (1991) interpreted technology deployment from two different perspectives: the objectivist and the subjectivist perspective. The objectivist view assigns technology the role of a "*discrete object ... capable of having an impact on social systems*" (p. 146), while the subjectivist interpretation is based on the premise of social action and human interaction. In Orlikowski and Robey's opinion objectivist interpretations seem to be mechanistic and do not allow us to foresee the real consequences of technology integration into existing social practices because they do not take into account the contextual and temporal nature of social action.

Based on the above interpretations new technologies can be viewed as 'hardware', the "*equipment, machines, and instruments humans use in productive activities*" (Orlikowski, 1992, p. 399), or social technologies that embrace "the generic tasks, techniques and knowledge utilised when humans engage in any productive activities" (p. 399). These philosophically contrasting interpretations assign different roles to technology. According to Orlikowski (1992), early organisational researchers have assumed technology to have "deterministic impacts" on organisational structures, which explains views related to the role of new technologies as 'a catalyst' or 'agent' of educational change and school structures. Other researchers have been focusing on "*the human action aspect of technology, seeing it more as a product of shared interpretations and interventions*" (pp. 399-400). Orlikowski (1992) argued that more recent studies have combined the two perspectives and drew inferences between technology as a resource and the agency of human actors in organisational contexts.

This new approach to understanding the consequences of technology integration emerged from Giddens' Structuration Theory (Giddens, 1984), where the abstract structures and human actors are in constant interaction (Giddens, 1984; Orlikowski, 1992). Giddens' Structuration Theory has been instrumental in understanding the interactions between human actors (teachers and learners), the structures and social contexts within which they operate (schools, classrooms, communities), and the structures (including rules and resources created by governments and schools) that have been influencing the social practices of teaching and learning with digital technologies.

Giddens (1984) argued that human actors and contexts of social interaction are "*positioned' relative to one another*" (p. xxv) "*along the coordinates of time and space that translate into the "character of the physical milieu of day-to-day life*" (p. xxv), embracing resources, rules and routines. Giddens maintained that routines or habitual action constitute the foundations of social life and provide its recursive nature. In his opinion routinisation is vital to human actors, granting them a sense of "trust and ontological security" (p. xxiii). In Giddens' opinion human actors try to make meaning of their social practices within a particular social context situated in time and space by "*reflexive monitoring*" (p. 5) of their activities. Through reflexive monitoring they rationalise their practices and develop theoretical understandings or personal theories of action. Reflexive monitoring and meaning-making help actors become knowledgeable agents capable of transforming their competence from 'practical consciousness' to 'discursive consciousness'. In other words, actors transition from the ability to perform the action to the ability to "*report discursively about their intentions, and reasons for, acting as they do*" (p. 6) which provides them with agency. Human agency is guided by intentions, and translates into the ability to "*intervene in the world*" (Giddens, 1984, p. 14), and/or the "ability to transform social relations to some degree" (Sewell, 1992, p. 20). The ability/power of agents to initiate change is both constrained and enabled by rules (or cultural schemas according to Sewell) and resources which constitute the structures within which they operate.

Giddens' premise that resources are media through which power is exercised is particularly interesting from the perspective of this study. It helps us understand the multiple tensions between structures and individual or collective agency in teaching and learning with new technologies that can result in reproduction of existing social practices, or alternatively, through new practices it can lead to innovation, evolution and educational change.

## 6. Concluding remarks

This chapter offered an overview of four influential theoretical frameworks that guided the integration of digital technologies in education in the second half of the 20th century. The epistemological stances of behaviourism, cognitivism, constructivism as well as sociological and organizational interpretations of digital technologies were examined in order to understand how knowledge was contextualised, how social practices of learning and teaching were constructed and how conceptual frameworks for technology integration have evolved from teacher centred and mechanistic approaches to learner centred flexible designs.

Given the magnitude of the impact of these theoretical shifts had on learning and pedagogical design in the 20th century it is anticipated that revisiting the above epistemological frameworks will help educators critically examine and rethink current models of learning and teaching with digital technologies.

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