The Effect of Interactivity in e-Learning Systems

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ABSTRACT

This book is based on research conducted to investigate whether interactivity yields a learning effect when used appropriately in e-Learning Systems, and whether this effect enhances learning. The importance of interactivity for success in learning has always been paramount; however, little scientific evidence can be found to support this importance (Sims, 2003; Leiner & Quiring, 2008). Thus, the book provides evidence of the impact of interactivity on e-Learning Systems considering three main agents: the learner, the teacher and the system (educational triangle). A key element often found to be related to learning and the three previously-mentioned agents is the concept of feedback. The use of interactivity as part of a feedback mechanism for enhancing learning is well documented in this book. Three empirical studies are presented that investigated interactivity within the educational triangle. These three studies were conducted based on the framework of positivism and action research paradigms. The first study, entitled "Interactive Pedagogical Feedback", aimed to gather evidence for how highly interactive pedagogically-designed formative feedback enhances students' memory and understanding. The two student groups to which the interactive conditions were added showed a significant difference in the post-test scores. A one-way ANOVA with a Turkey HSD post hoc test for all pair-wise comparisons reveals a significant difference between the transfer and no condition scenario. The second study, entitled "Interactive Audio Feedback", examined whether the speed enhancements of oral feedback improve the conditions for the production of the lecturer's feedback and the quality of the feedback delivered to the students. The use of the interactive condition reduces by 40 to 65 per cent the time it usually takes to prepare feedback for final assignments, and an unpaired Student's *t*-test shows significant differences in the use of the two conditions. The final study, "Interactive Texting Feedback", took a pedagogical approach to provide formative feedback to a student audience using mobile text messages. It aimed to determine whether Interactive Texting Feedback enhances the learning experience within the e-Learning environment. Inferential analysis demonstrated good correlations in the use and benefits obtained by the introduction of the interactive mechanism. The results indicated that interactivity is critical in promoting and enhancing effective

learning. Learning theories led by the generative theory of learning (Wittrock, 1974) and the principles of multimedia learning (Mayer, 2001) provide scientific explanation for these findings.

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Finally, my loving thanks go to all members of my family for their silent but strong support.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Human-technology interactions rule our lives with a clear purpose such as enhancing our lifestyles or supporting our present relationship with machines. Such interactions have been an important element in all human activities, from the earliest times to the present. Interactivity is tied to a long history of successful human events. Today, when interactivity is a core component of technology, this tendency has not diminished; on the contrary, it is growing at the same speed, or maybe even faster than technology. In education, for example, Technology-Enhanced Learning (TEL) uses interactivity to facilitate learning practices that have become ubiquitous (Chan et al., 2006). Learners can select their educational material and study at the place, time and pace that suits them as individuals, enabling them to be active learners. The importance of interactivity for success in teaching has been seen as fundamental for a long time (Webster & Hackley, 1997). This importance is emphasised to such an extent that it is claimed that students with higher levels of interaction will obtain more positive and higher levels of achievement (Fulford & Zhang, 1993). This book offers the reader a great opportunity to study and understand the important role that interactivity plays in the development of educational technology. It takes those interested in the future of education to the centre stage to show significant studies where an interactivity effect enhances learning and empowers the learner. Results corroborate the above-mentioned intrinsic relationship between levels of interactivity and levels of achievements.

Interactivity is changing the way we behave by increasing an individual's control over his or her own learning (Rogers, 2000). Since the introduction of the Internet, information is now in the hands of more individuals, with predictable consequences. One important consequence is the elimination of the intermediary in most business, service, and even academic transactions. In business, for example, there has been a transfer

of power from the advertising agency building the brand to the individual consumer (Einstein & Pollack, 2000). In the past, an agency forged a brand and delivered it to the consumer. In an unprecedented shift in paradigm, the consumer actually creates the brand over time using a variety of media resources. This paradigm shift is not exclusive to business, but it is seen in many other areas where individuals have been empowered with tools and decision-making power that were inaccessible before. The research in this book identifies interactivity as one of the essential factors that promote this paradigm shift. Technology in the hands of the learner requires mechanisms to ensure and validate the transfer of information. Several examples and experiments (see Chapter Four

Interactive Pedagogical Feedback) illustrate the support for such an important change in paradigm.

Interactivity is everywhere these days. If you walk into a library or a museum, there will be an interactive map with guided instructions. The television set was transformed a long time ago into an interactive TV to enhance the entertainment experience (Jiang et al., 2011). Interactivity provides the viewer with real-time interaction with the TV content production team to guarantee the best possible entertainment experiences, and the ability to watch, participate, influence and control what they see. The literature review in the book explores this ubiquitous nature of interactivity and indicates the important role interactivity has played in the design of instructional material (Mayer, 2005). In addition, feedback as a fundamental concept in teaching and learning has been investigated and its importance as an instrument in the improvement of education well documented (Smits et al., 2008).

1.2 Research background

In education, interactivity has changed the teacher and student roles (Rogers, 2000). The teacher-student relationship used to occur in a one-way direction, where students adopted a passive role. Today, this relationship has been transformed to a bidirectional exchange where students have an active position. Educators, to adapt to these innovative events, have also changed from instructional delivery to instructional design, and this has given birth to information technologists responsible for applying information technology to the content (Anson, 1999). Instructional designers, tied to this impressive chain of events, have moved from the educational philosophical approach of behaviourism to cognitivism, and then on to constructivism, in a systematic progression toward individualised instruction (Cooper, 1993). A conceptual map of the

relationship among these learning theories can be seen in MISSING. However, the book goes beyond this graphical representation to explain how these theories have evolved as a result of different phenomena that have been left unexplained. For example, cognitive theorists consider that behaviourism reduces complex human behaviour to simple cause-and-effect. In their quest to demonstrate that inside the mind complex processes have an active participation in learning, they not only presented the insufficiencies of behaviourism but developed a conceptual framework that explains their perspective (Köhler, 1927). Nowadays, the explosion of information in this digital era is represented in a section of the book that describes how "connectivism" portrays a new model that establishes a revolutionary concept of learning. Learning in this context is taken from the external cause-effect relationship, and/or the processes inside the mind, and placed outside as the act of recognizing patterns shaped by complex networks (Siemens, 2006).

This philosophical shift in paradigm through technology has found the appropriate environment (e-Learning) in which to demonstrate its potential and interactivity, and this is being used in an unprecedented way to enhance learning. Interactivity, as the ability to respond contingently to the learner's actions (Beauchamp and Kennewell, 2010), has been positioned as an important instrument for promoting leaning.

e-Learning, as the educational environment based on technology, is an innovative concept focused on the individual. Tavangarian et al. (2004) highlight this particular characteristic when they define e-learning as "all forms of electronic supported learning and teaching, which are procedural in character and aim to effect the construction of knowledge with reference *to individual* experience, practice and knowledge of the learner". However, e-learning is still in its infancy and its adoption, as with the implementation of any new technology, faces issues, such as the reduced usage of technology as an instruction delivery method and the ineffective use of technology to support learning (Kahiigi et al., 2007). In addition, a related constraint that is reducing support for the constructivist approach are the needs for customization of the content and learning material, and for an interactive relationship between the learner and the content that is being instructionally defined.

Many e-learning implementations fail because they just mirror common objects from the physical world, such as books, in a digital environment, without considering the environment and contextual characteristics.

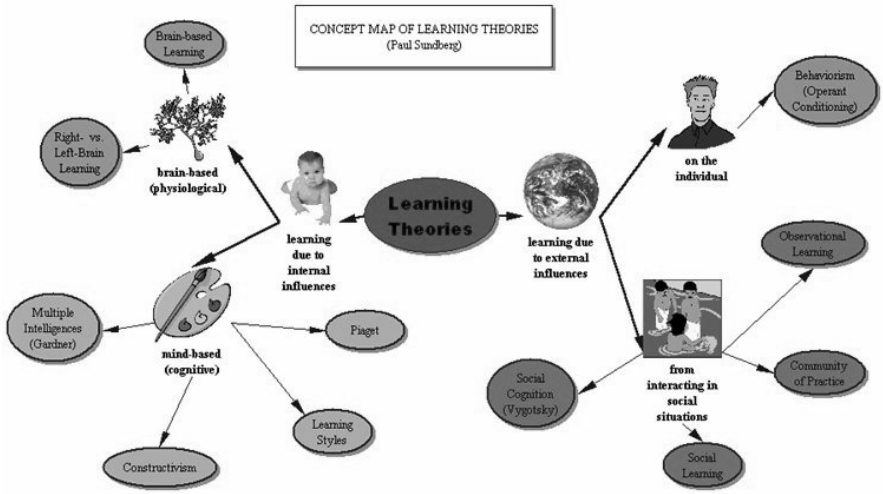

Figure 1: Concept Map of Learning Theories (Sundberg, P., 2003).

1.3 The research problem, aim and objectives

The challenge of this research is propelled by these emerging issues in e-learning that relate to interactivity. The main aim is to determine whether interactivity can enhance the learning experience by investigating its effects within a feedback context on three specific studies. The research undertakes this task by providing tangible evidence of the interactivity effects, identifying how interactivity affects the learning experience, and by investigating this effect within three different feedback contexts.

The importance of interactivity for success in learning has always been paramount. However, little scientific evidence can be found to support such a statement. Sims (2003), for example, comments that the concept of interactivity is frequently used to refer to an inherent quality of the medium and learning environment, with an underlying assumption that the interactive characteristics of communication with other learners or content objects is beneficial to the learning process. However, he does not perceive that tangible enlightenment is presented in the dynamics of interactivity. Leiner and Quiring (2008) argue that the user's perceptions of interactivity require more research as a central aspect in the new media context. The researchers previously mentioned clearly stated that the general perception is a lack of factual and scientific proof to support the argument. Thus, one of the research objectives is to provide this evidence.

This lack of evidence underpins the research and motivates the research question:

Can interactivity in an e-learning system enhance the learning experience?

Three main agents are identified in this process: the learner, the teacher and the system. Similar studies in the literature have called this relationship "the educational triangle" (Cumming, 1998; Wood et al, 1999). The effect of interactivity within these agents has been investigated to determine the impact on individualised learning.

An important element that also emerges from this question is related to interactivity and its ability to produce a learning effect when appropriately implemented in a particular system. Therefore, the research has the object of identifying how interactivity affects the learning experience in an e-learning setting. Since the main aim is the identification of learning as a result of the introduction of interactivity, the study of learning as a process of transferring knowledge is vital. Other effects may be present that enhance the learning experience given the reaction speed resulting from incorporating interactivity in another scenario or contextual situation.

Furthermore, this study has the object of investigating the effect of interactivity within a feedback context. Bransford et al. (2000) indicate that frequent feedback is essential for deep learning. Interactive feedback offers feedback quickly and at the appropriate frequency, to help keep motivation and interest in the topic taught. Feedback increases the amount of time dedicated to learning because it engages the learner in an interactive learning process. Research indicates that the time dedicated to learning is essential because it is approximately proportional to the amount of material being learned (Singley and Anderson, 1989).

Feedback is information communicated to improve learning by changing thinking or learner behaviour (Shute, 2008). The use of interactivity as part of a feedback mechanism for enhancing learning is well documented in the literature. Feedback is essential for learning because it is information communicated to improve learning by changing the learner's thinking or behaviour. Three empirical studies were designed to investigate the effect of interactivity within the previously mentioned educational triangle.

The first empirical study revolves around the concept of using formative feedback pedagogically designed to enhance learner skills. It is believed that interactivity incorporated into a computer-based system in the form of formative feedback will increase learning. Knowledge about appropriately implementing and embedding formative feedback within learning environments has recently taken more relevant position recently

(Bell & Cowie, 2001). Information about feedback and its characteristics is also highly important; for example, immediate constructive feedback offers a valuable contribution to the learning experience, but if feedback is provided too soon it seems to block relevant mental information processing activities and thus degrades learning (Requin & Stelmach, 1991).

The second study relates to enhancing teachers' capabilities to produce effective and quicker interactive feedback using audio, as for most people speaking is a much quicker form of communication than typing. These speed enhancements of speaking rather than typing are carried over to the process of creating feedback to enhance learning-related activities. The expansion of higher education has meant that, with large numbers of students, producing feedback can be a very time consuming task. This can have a knock on effect on the length and quality of individual feedback. There is a need, therefore, to find mechanisms to ensure that the quality and quantity of feedback is sustained or even enhanced.

The final study focuses on the system. It mediates the relation between the two main agents of the educational triangle: the teacher and the learner. The empirical study uses text messages (SMS) supported by a web-based response system to provide formative feedback to a student audience after educational content has been delivered. The objective of this experiment was to determine whether Interactive Texting Feedback is a valid and effective pedagogical approach to enhance the learning experience. The feedback system employed to communicate with teachers and learners is a logical and direct way to integrate technology with pedagogical practices and learning activities. Interactivity, as the essential component in technology, plays a key role in communication among the agents of this educational triangle.

1.4 The contribution of this research

From a theoretical point of view the book contributes to a conceptual framework for the understanding of interactivity in e-learning systems, identifies the important role interactivity has taken in all learning activities mediated by technology, and illustrates the implications of using interactivity within the educational triangle: the teacher, the learner and the system. The information contained in the book is useful for academics and institutions to improve their teaching, guide the design of instructional content and the efficiency of their learning delivery mechanisms. It could also be of utility to other researchers, or those in roles that require an understanding of interactivity.

Previous studies attribute apparent success or lack of success to enhance learning by using interactivity. This research also contributes from a practical perspective with significant evidence of the tangible effect of interactivity within the three particular agents of the educational triangle that combine in any learning experience. Moreover, the book constitutes a road map for those practitioners, lecturers, etc., interested in the design and implementation of sound academic content, production of audio feedback, and blending learning.

The contribution of the work described in this book has been recognised through the peer-reviewed publication of sub-sections of it in the following journals and conferences: Cases on Transnational Learning and Technologically Enabled Environments (book published by IGI Global (Palacios & Evans, 2010)); Conference on Innovations in Learning for the Future 2010: e-Learning in Istanbul, Turkey, (Palacios & Evans, 2010); International Journal of E-Adoption (Evans & Palacios, 2011); Fifth Mediterranean Conference on Information Systems MCIS 2010 (Evans & Palacios, 2011); 2010 International Conference in Cairo, Egypt. (Evans & Palacios, 2011); The International Conference in Education and Management Technology (ICEMT) (Evans & Palacios, 2011) and in the International Conference IADIS e-Learning 2011, Rome, Italy (Evans & Palacios, 2011).

1.5 The overall structure of the book

The overall structure of the book is designed around the concept of interactivity and how it enhances learning in three different feedback scenarios. This chapter has described the scope of this book by presenting the research background about interactivity, identified the research problem, the significance of this research, and the methodology to be followed to answer the research questions and to test the proposed hypotheses, and explain the overall structure of the book.

Chapter 2 reviews the literature in the areas of e-learning, interactivity, feedback delivery and the theoretical background to support the research. Major philosophical approaches are explained in this literature review to support these different perspectives of how people learn and how teachers educate. These teaching strategies vary across disciplines and they are conceived as pedagogical information that help students overcome difficulties and guide them through a typical path in order to achieve understanding.

Chapter 3 describes in general the methodology followed to provide validity and reliability to the research.

The next three chapters describe the experiments designed to test the effects of interactivity within feedback mechanisms embedded in the context of the educational triangle. Chapter 4 is about interactive pedagogical feedback. It focuses on the learner and how interactivity enhances his/her cognitive abilities. This empirical study is conducted to test the first hypothesis that interactivity in the form of retention and transfer ISAQ incorporated in a computer-based system increases learning.

Chapter 5 is about Interactive Audio Feedback for Enhancing Learning. Teachers' capability to produce quality feedback is enhanced by producing it in half the time that it takes to produce normal feedback. The Interactive Audio feedback study was designed to test the two following hypotheses: that "creating feedback in audio form is quicker than creating feedback in typewritten form" and "that feedback received in audio form is better quality than feedback received in written form".

Chapter 6 is more related to the mediator system in the pedagogical triangle. The Interactive Texting Feedback study uses action research methodologies to determine the effectiveness of interactivity in this context. It responds to the final hypothesis that interactive texting feedback is an effective approach to enhance learning practice.

And finally, Chapter 7 embraces a general discussion of the results found in the three experiments designed to test the effects of interactivity. It generalises the findings and relates to the appropriate theories to explain the phenomenon. It then addresses the limitations of this study and suggests directions for future research. Lastly, the conclusion is presented.

CHAPTER TWO

THE EFFECT OF INTERACTIVITY IN E-LEARNING SYSTEMS

2.1 Introduction

The present section considers the relevant literature relating to the effects of interactivity in different e-learning systems or TEL mechanisms. TEL refers to the support of any learning activity through technology (Manouselis et al., 2011) and is usually used synonymously with the term e-learning, although they do differ as TEL focuses largely on the technological support of any pedagogical approach that utilises technology. Although the utilisation of TEL is new, research on the subject has spanned three generations (Hakkarainen, 2009): the first generation studied computer-assisted learning from a cognitive perspective; the second-generation research focused on analysing patterns of participation (social view) in computer-assisted learning; and the third generation of research aimed to overcome the disparity between the cognitive (knowledge acquisition) and socio-cultural (participation) perspectives. This chapter establishes the bases for understanding the theoretical background supporting the research in interactivity and its effects in learning presented in this book. An explanation of e-learning is therefore relevant as the main environment where the research is going to take place.

e-Learning is a term that encompasses all forms of TEL, but tends to focus on pedagogy (Watkins, 2010). Indeed, e-learning is predicted to be the mechanism by which future students and organisations can facilitate learning practices that are independent of time, place and pace (Palacios & Evans, 2010a; Zhang et al., 2004). For example, educational technologies empower individuals in gaining international access to the academic resources of countries in which self-directed study and student autonomy are emphasised (Ziguras, 2001). Learners can select educational material and study in accordance with their own style and pace, enabling them to be active learners. The flexibility provided by these interactive technologies

does not constrain the learner in terms of location or time. Furthermore, it facilitates a more active role and personal development, and generally involves the support of any learning activity by means of technology. These learning activities are organised with the intention of improving students' knowledge, skills and competence.

According to Stergioulas (2004), there is a need to improve and consolidate the professional learning of the current learning systems that are seen in research policies and road maps designed for e-learning Technologies in Europe. In this context, e-learning is seen as a tool that minimises the time needed to prepare for future jobs in order to improve the current knowledge base and expertise and transform the process of continuous professional development.

Interactivity is a distinctive component within the modern world of technology, and, as an educational tool, it is perhaps the element that offers the best guarantee in education (Domagk, Schwartz & Plass, 2010). People have been interacting with their environment, absorbing knowledge or creating new experiences on top of previous ones from an early age (Hofer & Pintrich, 1997). Learning is considered the transformational process of increasing abilities to obtain goals (Washburne, 1936), and thus people and technology interaction are relevant within the process of learning. The extension and effect of these interactions has in learning are not well known. In addition, the effect of interactivity is vaguely registered in the literature from an academic perspective. Thus, the research developed in the chapters following intend to provide evidence of the types of effect interactivity cause in learning. Practical activities in real academic scenarios but under scientific control are evaluated and presented in next chapters.

Since the focus on learning alternatively shifts from technology to human cognition in order to take into account our ability to assimilate knowledge (Zuga, 2004), it is sensible to study several theories and concepts of learning in order to gain a better understanding of these issues and to support this research. Moreover, there is a paradigm shift (Rogers, 2000) from "teaching" to "learning" promoted by technology that has been evolving in recent decades. Fantuzzo (1992), for example, described the use of behavioural analysis in education to indicate that a teacher-centred approach was the cornerstone of resolving the educational challenges of that generation. In contrast, Geelan (2001) advocated the notion of "student-centred learning" as a popular and influential approach for students to control and develop own educational activities in a more constructivist framework. Interactivity seems to be at the centre of this paradigm shifting.

A great variety of learning theories have enriched the realm of education and other disciplines, but they overlap and coincide in their final outcome of learning (Guild, 1997). Learning theories moved into the psychological and sociological processes a long time ago, in the search for general ways to explain how we learn and how to do it more effectively (Zito & Schout, 2009). A learning theory is a method that describes how people learn and the complexity of the process of learning (Leonard, 2002).

There are four main philosophical approaches presented in this section that encompass a huge body of learning theories. Behaviourism, cognitivism and constructivism (see Figure 1) **follow a natural path of evolution from an emphasis on the environment** (behaviourism) **to an emphasis on the internal complexities of human learning** (cognitivism and constructivism) (Cooper, 1993). Nevertheless, an emergent approach named "connectivism" has come to emphasise how influential the use of network technology can be in learning (Siemens, 2005).

Behaviourism largely focuses on the observable changes of learner behaviour, while cognitive theories go beyond behaviour and explain mind-based learning. Constructivism considers learning as a phenomenon in which the learner actively constructs or builds new ideas or concepts. Connectivism on the other hand argues that learning today is too complex to be processed in the above-mentioned way. There is therefore a need to rely on the learning externally embedded within a network of people and/or technology that store, access, and retrieve knowledge (Siemens, 2006).

Furthermore, the experiments presented in the book were designed taking into account the principles that underpin these theories. For example Chapter Four Interactive Pedagogical Feedback investigates the concept presented in the cognitive model of learning (Sweller, 1988) to envisage a new mechanism to enhance memory's capacity. However, there is no intention to apply in this research the entire theoretical concepts presented in this literature review. They intend to illustrate how they have evolved and how they are interconnected with each other. The following sections in this chapter will present a more complete explanation of each of these theories.

2.2 Learning as Behaviour

Behaviourists concentrate on observing changes in behaviour (Skinner, 1953). Indeed, behaviourism is a theory of learning that mainly focuses on the observable changes in learner behaviour and discounts mental

activities. Behaviour theorists consider learning as nothing more than the acquisition of new behaviour, and Skinner (1953) was influential in defining behaviourism. The theory identifies conditioning as the main element of the learning process and, according to Skinner (1953), classic conditioning and behavioural or operant conditioning are the two different types of conditioning.

Classic conditioning occurs when a physiological reaction is triggered by a stimulus (Figure 2). Pavlov (1906) highlights how one can change the stimulus part of a stimulus-response pattern (such as salivation) to something neutral (such as turning on a light), and yet generate the same response. Pavlov observed that the dogs started to salivate as soon as they saw the person who usually brought the food, enabling him to demonstrate that any neutral stimulus could be associated with food and thus elicit the food response, even when no food was present. The original stimulus and response to this stimulus are the "unconditioned stimulus" and the "unconditioned response", with the introduced neutral stimulus and learned response known as the "conditioned stimulus" and the "conditioned response", respectively. Pavlov's work on the accumulation of information and classical conditioning has been continued, but Bitterman (2006) considers there has been little conceptual progress. From the classical conditioning perspective (Pavlov, 1906), learning activities and the context in which they are performed should create or promote pleasant emotions, such as enthusiasm, excitement or enjoyment. These emotions will motivate learners in the completion or better performance of any learning task and will ensure that they actively participate in the experience. Another educational implication of behaviourism relates to measuring the impact of changes on behaviour. Evaluation thus plays a fundamental role in determining that learning has taken place. Behavioural or Operant Conditioning occurs when a response to a stimulus is reinforced and operant conditioning can be considered a feedback system: if the presence of a reward or reinforcement follows the response to a stimulus, then the response becomes more probable in the future. Skinner (1953; Skinner, 2009) used reinforcement techniques to teach pigeons to dance and bowl a ball in a mini bowling-alley. Behaviourism has been used for a significant period of time to encourage positive behaviour and deter negative behaviour (Ormrod, 2004).

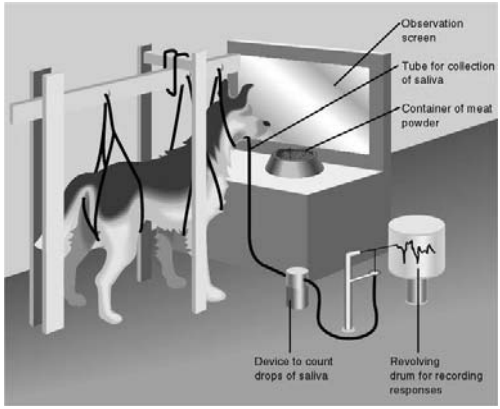

Figure 2: Classic Conditioning

In terms of *operant conditioning*, cultivating good habits through the repetition of stimulus-response exercises is part of normal classroom activities: the use of reinforcement and punishment constitutes a fundamental component in contemporary education, and is derived from the practice of behaviourism. Rewards that reinforce positive behaviour in order to increase the probability of a response, such as publicly praising students' skills and the recommendation of special projects, are the hallmarks of a good teacher. Positive reinforcement involves the presentation of the stimulus after the response, while negative reinforcement is employed to prevent or avoid an adverse condition; for example, submitting all assignments on time results in the lowest grade being avoided. This increases a response through the removal of the stimulus, which is usually an adverse or unpleasant one: for example, the removal of anxiety can be a very important negative reinforcer. Although positive and negative reinforcement increases learner responses, punishment decreases the responses expected; this is because punishment involves presenting a strong stimulus that decreases the frequency of a particular response. Thus, punishment is quite useful in quickly eliminating undesirable behaviours; an example of this is late assignments being given a zero grade.

Interactivity is connected to the behaviourist concept and Skinner's (1953) idea that information should be presented in small amounts has had a profound impact on educational software in which reinforcement plays a fundamental role: increasing the frequency of reinforcement by reducing the size of the information presented yields more effective results (Sims,

1996). In fact, early authoring tools for programmed instruction modules were originally designed in line with behaviourist principles. Corrective feedback, consistently used by behaviourists, is also a fundamental component of multimedia design. According to Hartsell (2006), interactivity is implemented in tutorials, using corrective feedback, in order to reward learners who accurately answer questions with audible comments. Gagne's (1962) work with the military strongly influenced the design of instructional materials and the development of instructional software. Through his work, Gagne stated how the interaction only allowed students to respond to questions posed by the instructor.

However, the application of behaviourism principles fails to address two important concerns in instructional design (Chase, 1985). The first is the lack of effective implementation of technology tools, such as computers and interactive media. To overcome this, realistic educational implementations had to be developed. The other is the production of low-level skills programmes that are unable to represent complex conceptual behaviour. These factors were borne in mind while designing and developing the experiments implemented in the book because they were considered relevant in keeping the research up to date. Since behaviourist ideas are outdated, the inclinations on the research fell into more technological orientated approaches.

2.3 Cognitive Theory

Cognitive learning theory describes how people or animals learn by understanding their mental processes and how they organise, store and relate old and new information, scripts and schema (Sweller & Chandler, 1994). Cognitive theory refuses to accept behaviourism as the only explanation for the human acquisition of knowledge, believing that behaviourism reduces complex human behaviour to simple cause-and-effect. In their quest to present the insufficiencies of behaviourism, gestalt psychologists (Köhler, 1927) demonstrate the pitfalls of the behaviourist concept of learning in their experiments to show that people are simply not programmed entities that respond to environmental stimuli: they are rational beings that require active participation in order to learn and their actions are a consequence of the processes developed in their minds. Behaviour is a manifestation of what takes place in the learner's mind. The shift from behaviourism to cognitivism occurs gradually, and Hartley (1985) based it on the short- and long-term memory paradigm.

In order to understand a wide range of cognitive functions, the constructs of working memory (WM), short-term memory (STM) and

long-term (LTM) memory are central to the cognitive learning theory. However, there is a lack of consensus in the literature in what these constructs represent, and how to distinguish them from one another. Terms such as "memory" and "storage capacity" are part of the cognitive vocabulary and are part of the computer jargon terminology. In the computer industry, memory is a part of a computer in which information is stored for immediate use by the central processing unit. Storage capacity is related to the maximum number of bits, bytes, words, or items that can be held in a memory system (Collins, 2000). "Memory" and "storage capacity" usage is similar in a cognitive context. People's memory is determined by the limit in the duration for which an item can remain active in STM without rehearsal (Cowan, 2001). Although memory capacity to storage is seven chunks (Miller, 1956), depending on people's differences this can increase or decrease by two chunks. Chunking, in psychology, is a phenomenon whereby individuals group responses when performing a memory task.

In addition, storage capacity is time-limited rather than capacity limited (Cowan, 2001). Rose et al. (2010) attempted to differentiate these constructs by comparing the effects of depth of processing on WM and LTM using a levels-of-processing (LOP) span task procedure that involved processing to-be-remembered words based on their visual, phonological or semantic characteristics. Rose et al. concluded that WM involved retrieval from LTM memory, and that it is affected by the match (or mismatch) between initial processing and subsequent retrieval.

The term working memory implies a system for the temporary holding and manipulation of information during the performance of a range of cognitive tasks, such as comprehension, learning and reasoning (Baddeley, 1986). Indeed, the term is used interchangeably to describe what is also called STM, primary memory, immediate memory, operant memory or provisional memory. WM emphasises the notion of the manipulation of information rather than passive maintenance (Atkinson & Shiffrin, 1968) and can be considered a more dynamic and complex STM construct (Baddeley & Hitch, 1974). Recently, Baddeley suggested that WM may be considered as an interface between STM and LTM, and thus he modified his original model by adding a new component, the episodic buffer, in order to accommodate the way in which WM and LTM interact.

It is important to emphasise that the interaction between storage and processing is controlled by selective attention to the subset of elements in working memory that may be manipulated at any moment. The mind's ability to direct its inner awareness upon a particular target in WM has been the predominant focus of attention (Cowan, 1995). Cowan (1995)

and other researchers (Baddeley, 1986) believe that WM is activated information along with central executive processes. They have therefore developed a framework that integrates attention and memory. The focus of attention capacity has a limit of about one element (Garavan, 1998); however, it can be expanded to four elements with practice (Oberauer, 2006). Interactivity plays a fundamental role in this practice, as demonstrated in the experiment developed by Verhaeghem (2005). Within this framework, WM consists of three embedded components: the activated part of long-term memory, the region of direct access and the focus of attention.

Working memory is used as an area for the storage of short-term information, including separate auditory and visual working memories (Baddeley, 1986). In later research, Baddeley (1992) asserted that the working memory is organised into a visual-spatial sketch pad for visual image manipulation and the phonological loop, which handles speech-based information.

Short-term memory, however, is used to retain information for short periods. WM and STM are considered different constructs, but are highly related (Engle et al., 1999). In fact, the two constructs have been used synonymously for so long that many of the tasks depicted in the literature as working memory tasks reflect a common construct. The short-term store has a working memory component, a sort of mental notepad that is used to manipulate information in consciousness. STM refers to the activated elements in this memory model, whereas WM is a larger component that incorporates the activated elements and the executive processes.

STM is related to the current contents of consciousness, while LTM comprises memories previously encoded in the remote past that must be brought back into consciousness through the retrieval process (Atkinson & Shiffrin, 1968). LTM has no known limit to its storage capacity, and verbal elements are normally coded in terms of their semantic characteristics (Craik & Lockhart, 1972). Thus, information stored in the LTM is very sensitive to the depth to which memory items are processed when they are initially encoded. Structural memory items, such as phonological or visual elements, usually lead to lower levels of retention than semantically processed memory items such as concepts (Craik & Lockhart, 1972). Long-term memory is the resident knowledge and skills acquired and held in a permanently retrievable area.

In summary, a cognitive model of learning (Sweller, 1988) is built based on three memory types: sensory memory, working memory, and long-term. These memories have limited capacity. Sensory and working