Real–Time Thinking in the Digital Era

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INTRODUCTION

In 2004, Eshet-Alkalai published a 5-skill holistic conceptual model for digital literacy, arguing that it covers most of the cognitive skills that users and scholars employ in digital environments, and therefore providing scholars, researchers, and designers with a powerful framework and design guidelines. This model was later reinforced by task-based empirical research (Eshet-Alkalai & Amichai-Hamburger, 2004). Until today, it is considered one of the most complete and coherent models for digital literacy (Akers, 2005); it is used as the conceptual design infrastructure in a variety of educational multimedia companies and was also described in the *Encyclopedia of Distance Learning* (Eshet-Alkalai, 2005). The conceptual model of Eshet-Alkalai consists of the following five digital literacy thinking skills:

1. **Photo-Visual Digital Thinking Skill:** Modern graphic-based digital environments require scholars to employ cognitive skills of "using vision to think" in order to create photo-visual communication with the environment. This unique form of digital thinking skill helps users to intuitively "read" and understand instructions and messages that are presented in a visual-graphical form, as in user interfaces and in children's computer games.
2. **Reproduction Digital Thinking Skill:** Modern digital technologies provide users with opportunities to create visual art and written works by reproducing and manipulating texts, visuals, and audio pieces. This requires the utilization of a digital reproduction thinking skill, defined as the ability to create new meanings or new interpretations by combining preexisting, independent shreds of digital information as text, graphic, and sound.
3. **Branching Digital Thinking Skill:** In hypermedia environments, users navigate in a branching, nonlinear way through knowledge domains. This form of navigation confronts them with problems that involve the need to construct knowledge from independent shreds of information that were accessed in a nonorderly and nonlinear way. The terms *branching* or *hypermedia thinking* are used to describe the cognitive skills that users of such digital environments employ.
4. **Information Digital Thinking Skill:** Today, with the exponential growth in available information, consumers' ability to assess information by sorting out subjective, biased, or even false information has become a key issue in training people to become smart information consumers. The ability of information consumers to make educated assessments requires the utilization of a special kind of digital thinking skill, termed *information skill*.
5. **Socio-Emotional Digital Thinking Skill:** The expansion of digital communication in recent years has opened new dimensions and opportunities for collaborative learning through environments such as knowledge communities, discussion groups, and chat rooms. In these environments, users face challenges that require them to employ sociological and emotional skills in order to *survive* the hurdles that await them in the mass communication of cyberspace. Such challenges include not only the ability to share formal knowledge, but also to share emotions in digital communication, to identify pretentious people in chat rooms, and to avoid Internet traps such as hoaxes and malicious Internet viruses. These require users to acquire a relatively new kind of digital thinking skill, termed *socio-emotional*, because it primarily involves sociological and emotional aspects of working in cyberspace.

The publication of Eshet-Alkalai's (2004) model of digital thinking skills has led to an extensive debate within the community of instructional technology designers, researchers, and educators, as to its validity and completeness, and a special panel in *ED MEDIA2005 Conference* (Montreal) was dedicated to it. This discussion (Aviram & Eshet-Alkalai, 2006) confirmed the validity and value of the model, but indicated that it lacked a sixth thinking skill: the *real-time thinking skill*, which relates to the ability of users to perform effectively in advanced digital environments, mainly high-tech machines, multimedia games, and multimedia training environments that require the user to process simultaneously large volumes of stimuli which appear in real time and at high speed. In the present article, real-time thinking is introduced as the sixth digital thinking skill, which completes the conceptual model of digital thinking skills.

BACKGROUND

The rapid development in digital technologies in recent decades confronts users with situations that require them to master a variety of technical, sociological, and cognitive skills, collectively termed *digital literacy* (Hargittai, 2002; Lanham, 1995), that are necessary to perform effectively in digital environments. Digital literacy is more than just the technical ability to operate digital devices properly; it comprises a variety of cognitive skills that are utilized in executing tasks in digital environments, such as surfing the Web, deciphering user interfaces, and chatting in chat rooms. Digital literacy has become a "survival skill" in the technological era—a key that helps users to work intuitively and effectively in executing complex digital tasks (Lazar, Bessiere, Ceaparu, Robinson, & Shneiderman, 2003).

In recent years, extensive efforts have been made to establish models that describe the cognitive skills that users employ in digital environments (e.g., Hargittai, 2002; Wegerif, 2004; Zins, 2000). Unfortunately, these efforts are usually local, focusing on a selected and limited variety of skills, mainly information-seeking skills (Zins, 2000) and, therefore, they do not cover the full scope of digital literacy. The present article presents real-time thinking, as an additional, sixth skill, in Eshet-Alkalai's (2004) holistic conceptual model of thinking skills in the digital era.

WORKING IN REAL-TIME ENVIRONMENTS

Imagine a pilot flying a jet, a driver driving a car, or a child playing a video game. In all these situations the users are exposed to a large flux of stimuli that *bombard* their cognition in real time, at very high speed, and in random temporal and spatial distribution. In all these situations the key to the users' successful performance is their ability to manage and synchronize these stimuli effectively. When operating such environments, users need to split their attention, reacting to various kinds of stimuli that appear simultaneously in different places on the monitor; they have to be able to execute different tasks simultaneously (multitasking); they need to be able to rapidly change their angle of view and perspective of the environment; and they have to respond to feedback that appears in real time. And above all—they have to quickly and effectively synchronize the chaotic multimedia stimuli into one coherent body of knowledge.

Today, situations that require real-time and high-speed processing of simultaneous large fluxes of information have become common in our lives, mainly in operating multimedia computer programs and advanced machines. This requires that users of today's digital environments master a special kind of thinking skill, here termed *real-time thinking*. Of course, real-time thinking is not new; it has been utilized ever since humans began to think and to synchronize information simultaneously in order to create knowledge. But in the digital era, with the central role of fast computers, multimedia environments, and devices that can process and present information in real time and at high speed, real-time thinking has become a critical skill. Real-time thinking situations usually require the utilization of split-attention skills in order to manage simultaneously large volumes of stimuli (text, sound, and images) that appear in real time and at a very high speed.

Today, most studies of real-time situations are conducted by researchers in the field of operations research, who explore human performance in aircrafts (Hamblin, Naidu, & Miller, 2006; Roessingh, 2005), cars (Casimir & Gilchrist, 2002) and other real-time working environments. Very little research has been done on the "soft" pedagogic aspects of real-time learning, such as digital games and language acquisition in real-time environments (Eshet-Alkalai, & Chajut, 2006; Pemberton, Fallahkhair, & Masthoff, 2004).

DIMENSIONS OF REAL-TIME THINKING

Simultaneous Synchronization

According to the *dual channel model* (Mayer, 2001), in multimedia environments, real-time stimuli are processed in parallel, independent channels (auditory-verbal and visual-pictorial), and the users' ability to synchronize them effectively is a major factor in their performance (Gopher, Weil, & Bareket, 2004). This model is useful for describing information processing in most multimedia environments such as microworld simulations (e.g., flight or driving simulations, in which the users operate a simulated aircraft or car). In the operation of these simulations, the users employ real-time thinking as they process large volumes of digital information simultaneously. Studies show that practicing real-time thinking in such real-time simulations is useful for improving synchronization ability, and therefore performance, of pilots (Gopher et al., 2004) and drivers (Barkan, Zohar, & Erev, 2003). However, information processing is not limited to these two channels only; in real-life situations, people utilize additional channels for processing real-time information, such as emotions and tactile information, which makes real-time thinking much more complex. Leuchter and Urbas (2002) showed that effective real-time thinkers are capable of synchronizing many channels of information processing simultaneously. One of the common applications of real-time synchronization is the case of language acquisition from subtitled films and from *living books*—computer-based storytelling multimedia programs (http://www.livingbooks.com). In living books, children simultaneously hear a story and watch its text on the monitor. Studies have shown that children acquired a foreign language by synchronizing subtitles with narration in both living books (Eshet-Alkalai & Chajut, 2006) and interactive television (Pemberton et al., 2004).

High Speed

In addition to the simultaneous synchronization of information, modern, real-time digital environments are characterized by the fact that information passes through the information processing channels at very high speed. In car racing, fighting video games, or in flight simulations, users are *bombarded* with a large variety of high-speed moving stimuli (e.g., enemies, snipers, and road obstacles) as they move quickly from place to place and from scene to scene in the game environment. This requires that users not only master simultaneous synchronization skills, but also be able to respond quickly to obstacles. The response rate aspect of real-time thinking was investigated in a variety of real-time situations such as games (e.g., Erev, Luria, & Erev, 2006), simulations that require real-time thinking (Seagull, Wickens, & Loeb, 2001) and real-time situations drawn from daily life such as car driving (Barkan et al., 2003). These studies showed that the best performers were those who were able to process information quickly, indicating the crucial role of high-speed information processing in real-time situations. Roessingh (2005) found that flight simulators were useful in increasing the response rate of pilots and their ability to manage fast-moving stimuli. Eshet-Alkalai, and Chajut (2005) investigated the performance of gamers in shooting and car racing, real-time game environments, in which the users' success depends on their ability to respond in real time to fast-moving obstacles and stimuli. They found that the younger participants were the best real-time performers in their response rate and their ability to retain a high level of performance over a long period.

Attention Management and Multi-Tasking

In most real-time environments, users are required to be able to split their attention and respond simultaneously to stimuli that appear in different areas on the screen, and at the same time to conduct multitasking, physical activities such as operating the keyboard and the mouse simultaneously. For example, in *FIFA*—a real-time soccer-playing environment (http://fifa06.ea.com/) multiple events take place simultaneously on the screen: One player leads the ball, another runs after him, and on the other end of the yard, the gatekeeper is away from the gate. In such an environment, gamers must be able to split their attention among independent events in order to analyze the situation and adopt the most appropriate playing strategy. Gopher (1982) and Gopher et al. (2004) studied attention management and multitasking problems that relate to the management of real-time environments such as flight and basketball training simulations. Participants were tested on their ability to simultaneously split attention and relate to different types of stimuli such as sound, pictures, and text. Split attention and multitasking management—the ability of users to turn their attention simultaneously to different stimuli and to conduct different simultaneous tasks, was found to be the most significant factor in determining the level of performance and real-time thinking, and the best predictor of success in a flight course (Gopher, 1982). The combination of constant attention shifting and multitasking in real-time environments requires that real-time thinkers have a high degree of cognitive flexibility that helps them in shifting perspectives effectively. Erev and Gopher (1999) summarized the major aspects of selective attention strategies and showed that the ability to perform effectively in real-time environments is closely related to a high level of the user's selective attention management.

Multiple Perspectives

Many real-time environments, especially multimedia games and simulations, provide users with the ability to shift their perspectives, angles of view, and degree of resolution, as they work. For example, in FIFA, the user can shift constantly between different views: the single-player view; the gatekeeper view, and the entire system view; in Flight Simulator, the user can shift between the interior in-plane view and exterior view. The flexible shifting of perspectives in real-time environments may improve users' performance (Erev & Gopher, 1999) but it also requires them to be able to synthesize these multiple perspectives, accessed in real time, into a coherent decision or body of knowledge. For example, in Flight Simulator, the multiple perspectives that the users gain help them to select the flight route and make appropriate combat decisions. These situations require the utilization of a high level of real-time thinking. Roessingh (2005) found that pilots' ability to employ multiple perspectives in real-time flight simulations is closely related to their ability to successfully create mental models of the flight route and the interior of the plane.

Real-Time Feedback

Just-on-time feedback is an integral part of most real-time environments. These environments provide users with constant feedback that helps to improve their performance. For example, in typist training programs (e.g., http://www.21stsoftware.com/SS_Typing.htm), in car racing, multimedia simulations, or sport games, the system provides vocal and visual feedback on users' mistakes and achievements. This enables gradual improvement in performance through a process of successive approximation. Such a process requires that users be able to manage a steady flow of real-time feedback of a different nature, in order to perform effectively. The positive impact of real-time feedback on the performance of users was illustrated in recent years by various empirical studies (e.g. Barron & Erev, 2004; Erev et al., 2006).

FUTURE TRENDS

Real-time digital thinking is a skill that evolves side by side with present-day technological developments. In the future, with the rapid evolution of technologies, mainly multimedia and game technologies, we will face increasingly more complex real-time environments, in which more stimuli occur much faster and users are required to manage more multiple-perspective and multitasking situations. This will open new frontiers for users, but at the same time, confront them with an ever-growing assortment of problems and challenges that must be addressed in order to perform effectively.

CONCLUSION

Real-time digital thinking is a cognitive skill that helps users of present-day digital environments to work effectively and to create knowledge from large volumes of information that are introduced simultaneously and at high speed. It is a pivotal skill for users of many present-day digital environments such as multimedia environments, digital games, and advanced machines (e.g., aircraft and cars). Studies from the field of operations research show that a high level of real-time digital thinking is critical for successfully operating real-time environments.

In the present article, real-time thinking is presented as a sixth digital thinking skill that completes Eshet-Alkalai's (2004) holistic conceptual mode of digital thinking skills, in which an attempt was made to represent digital literacy and human thinking skills in the digital era with five digital thinking skills.

Effective real-time thinkers are able to successfully process simultaneous stimuli in real time, manage stimuli that appear at very high speed, split their attention effectively, conduct multitasking jobs, simultaneously manage the multi-perspective representations of the environment, and utilize effectively the just-on-time feedback provided by the system.

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KEY TERMS

Channel Model: A model which suggests that in multimedia environments information is processed in parallel independent channels: verbal and visual-pictorial.

Digital Era: A term used to describe today's era, in which digital technologies are used in almost every aspect of life.

Digital Literacy: A term used to describe the ability of users to perform in digital environments.

Digital Thinking Skills: A refinement of the term *digital literacy*, describing the variety of thinking skills that comprise digital literacy.

Real-Time Digital Thinking: A term used to describe the thinking skill that is employed in many of today's digital environments. In such environments, the user needs to manage large volumes of information, perspectives, and tasks that are introduced in real time and very high speed.

Real-Time Digital Environment: A term used to describe digital environments in which users need to manage in real-time simultaneous stimuli, multiple perspectives, and multitasking.

Synchronous Stimuli: Stimuli that are emitted simultaneously by the environments. For example, simultaneous sound, text, and images to which users of digital environments are exposed.