You Can Teach Old Dogs New Tricks: The Factors That Affect Changes over Time in Digital Literacy

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Executive Summary

The expansion of digital technologies and the rapid changes they undergo through time face users with new cognitive, social, and ergonomic challenges that they need to master in order to perform effectively. In recent years, following empirical reports on performance differences between different age-groups, there is a debate in the research literature concerning the nature of these differences: whether they reflect age-related cognitive abilities of the users, or that they are related to the usability and experience of users with the technologies.

This study attempts to establish whether changes in digital literacy, through a period of five years, are age-dependent or the result of experience with technology. The study is based on empirical findings from two independent studies of Eshet-Alkalai & Amichai-Hamburger (2004), which investigated digital literacy skills among different age groups, and of Eshet-Alkalai and Chajut (2009), which investigated changes over time in these digital literacy skills among the same participants five years later. In order to distinguish between the age-related and the experience-related factors, the present study reports on findings from control groups of a similar age and demographic background, which were tested with tasks similar to Eshet-Alkalai & Chajut (2009).

Results show two major patterns of change over time: (1) closing the gap between younger and older participants in tasks that emphasize experience and technical control (photo-visual and branching tasks); (2) widening the gap between younger and older participants in tasks that emphasize creativity and critical thinking (reproduction and information tasks). Based on the results from the control groups, we suggest that experience with technology, and not age-dependent cognitive development, accounts for the observed life-long changes in digital literacy skills. Results, especially the sharp decrease in information skills, suggest that the ability to find information or use digital environments does not guarantee an educated or smart use of digital environments.

Keywords: digital literacy; literacy; change over time; information literacy; visual literacy

Introduction

The proliferation of digital technologies during the digital era confronts individuals with situations that require the utilization of an ever-growing assortment of technical, cognitive, emotional, and sociological skills that are critical for effective performance. In recent literature, these skills have been collectively termed 'digital literacy' (Ba, Tally & Tsikalas, 2002; Bawden, 2001; Hargittai, 2005; Marsh, 2005). Despite its extensive use in the literature, there are only a few

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theoretical models of digital literacy (Ba et al., 2002; Bawden, 2001; Bruce, 2003) and the lack of sufficient empirical studies (Hargittai, 2002) limits our knowledge about the utilization of digital literacy among specific gender, age, or social groups. Eshet-Alkalai (2004) and Aviram and Eshet-Alkalai (2006), published a comprehensive conceptual model of digital literacy, which is comprised of six literacy skills, arguing that it encompasses all the cognitive challenges faced by users of present-days digital environments as follows:

- **Photo-visual literacy skill:** Modern graphic-based digital environments require scholars to employ cognitive skills of "using vision to think" (Tuft, 1990) 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 (Shneiderman, 1998).
- **Reproduction literacy skill:** Modern digital technologies provide users with opportunities to create visual art and written works by reproducing and manipulating text, 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 pre-existing, independent shreds of digital information as text, graphic, and sound (Benjamin, 1994)
- **Branching literacy skill:** In hypermedia environments, users navigate in a branching, non-linear way through knowledge domains. This form of navigation confronts them with problems that involve the need to construct knowledge from independent sources of information that were accessed in a non-orderly and non-linear way (Spiro, Feltovitch, Jacobson, & Coulson, 1991). The terms '"branching", "lateral" or "hypermedia" thinking' are used interchangeably to describe the cognitive skills employed by users of such digital environments.
- **Information literacy 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 (Eshet-Alkalai & Geri, 2007, 2009). The ability of information consumers to make educated assessments of information requires the utilization of a special kind of digital thinking skill, termed "information skill" (Bruce, 2003).
- **Socio-emotional literacy skill:** Users of collaborative digital environments, such as knowledge communities, discussion groups, and chat rooms, are required to employ sociological and emotional skills in order to perform effectively in the mass communication of the cyberspace (Garrison, Anderson, & Archer, 2000). This new kind of digital thinking skill is termed "socio-emotional"
- **Real-time thinking skill:** Present-day multimedia environments, such as simulations and games, require that users process simultaneously large volumes of stimuli that "bombard" their cognition repeatedly. The ability of users to perform effectively in these environments is termed "real-time thinking" (Eshet-Alkalai, 2008a).

This paper synthesizes empirical findings from two studies (Eshet-Alkalai & Amichai-Hamburger, 2004; Eshet-Alkalai & Chajut, 2009) that explored the digital literacy skills of users from different age groups and the changes through time in these skills, in order to distinguish between the two major factors that account for the changes through time in digital literacy skills - - age and experience. This distinction is crucial for digital literacy studies, because unlike most everyday circumstances, where age is usually associated with experience, in the digital era, the opposite is true, with the younger users being more experienced than the older ones.

Mastering Digital Literacy Skills

In 2002, Eshet-Alkalai and Amichai-Hamburger (2004), tested the performance of users from different age-groups with tasks, that required the utilization of the aforementioned digital literacy skills (see, Eshet-Alkalai, 2004). Participants were 60 individuals of a similar demographic background, from agricultural communities in the Upper Galilee (kibbutz or moshav), northern Israel. All participants were selected randomly and volunteered for the research. They consisted of three age-groups: (1) twenty 11th grade high school students (average age, 16.9 years) from a regional high school, (2) twenty 3rd year college students (all from Tel Hai Academic College, Education and Economics departments, ages 24–30; average age, 26.4 years), and (3) twenty 30–40 year old adults who graduated from a college or university (average age, 36.5 years). Each participant group was composed of 10 males and 10 females. All participants had advanced computer skills; they all used computers in everyday life for word processing, E-mail communication, and Internet surfing. All had some experience in working with databases and preparing computer presentations using *PowerPoint*. Each participant was given the following tasks:

- **Photo-visual thinking skill**: They were asked to decipher the graphic user interface of a new interactive multimedia computer program for creating theatre stages and to build a theater stage of their own with it.
- **Reproduction thinking skill**: Participants were given a short paragraph and were asked to assign it a new meaning by reproducing and rearranging sentences, words, and letters, allowing the addition of only a few words of their own.
- **Branching thinking skill**: Participants were assigned an Internet tourist site and were asked to plan a detailed trip to a country they had never visited before. Executing the task required participants to employ branching literacy skills in order to construct a body of knowledge (tour plan) from a non-linear, hyper-textual navigation through a (geographical) knowledge domain (an Internet site).
- **Information thinking**: Participants were assigned a news event that was published in five different Internet news resources and were asked to write a critical report, which describes manipulations, bias, and falsification in the different news resources.

Participants' performance in each task was graded by three independent referees, based on a comprehensive list of evaluation guidelines. The validity and reliability of the grading system is illustrated by the close similarity between the referees' grades (r= 0.91-0.98).

The main findings of Eshet-Alkalai and Amichai-Hamburger (2004) were that the younger participants (High-School students) performed significantly better than the adult participants (30-40 years old) in skills that required mastering and experience with computer programs (i.e. photo-visual and branching thinking tasks). On the other hand, the adult participants performed significantly better than the younger participants in tasks that required a critical and creative usage of technology (i.e. information and reproduction thinking tasks).

Changes through Time in Digital Literacy Skills

In recent years, with the wide penetration of digital work environments into almost every aspect of life and their usage by members of almost every age-group, there has been lively discussion in the research literature concerning the nature of changes through time in digital literacy among different groups of users (e.g., Carrington & Marsh, 2005; Eshet-Alkalai & Geri, 2007, 2009; Tyner, 2003). In order to contribute to this discussion, Eshet-Alkalai and Chajut (2009), investigated in 2007 changes in digital literacy skills over a period of five years (2002-2007), using the

same participants who had been tested by Eshet-Alkalai and Amichai-Hamburger (2004), using similar tasks and data analysis methods.

Comparing the performance of the same group of participants between 2002 and 2007, revealed two distinct patterns of change in digital literacy over time (Figure 1): (1) A trend of **closing** the gap between younger and older participants in usability-experience skills that require experience in using the technology, and (2) A trend of **expanding** the gap in skills that require creative and critical thinking.

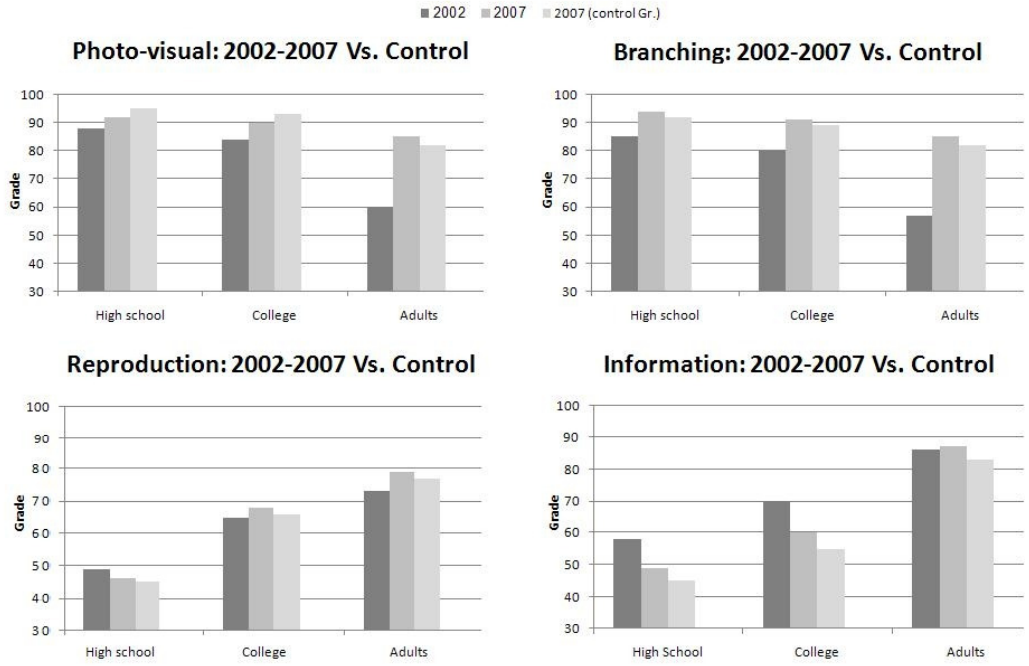

Figure 1. **Changes through time in digital literacy skills between 2002 and 2007.**
The significant differences between 2002 and the control-group of 2007, indicate that changes through time in digital literacy skills are explained by usability-experience.

2002: Data from Eshet-Alkalai and Hamburger (2004)
2007: Based on data from Eshet-Alkalai & Chajut (2009)
Control group (2007): Based on data from Eshet-Alkalai & Chajut (2009)

Usability-experience: Closing the gap

In the tasks that required a high usability level and experience in using digital environments (i.e., photo-visual and branching skills), a significant improvement in performance of the adults group was observed, whereas the improvement among the younger participants was small. Consequently, despite the fact that the younger participants maintained their "superiority" in performance, the gap between the two groups had decreased significantly.

Creative/critical skills: Expanding the gap

In the tasks that required critical thinking (information task) and creative thinking (reproduction task), a significant deterioration in performance was found in the performance of the younger participants, whereas the older ones improved slightly. Consequently, the gap between the older and the younger participants expanded to the favor of the older participants.

Usability-experience or generation-gap: Which factors affect changes in digital skills?

In recent years, the growing number of reports on the significant differences in digital skills between users of different age-groups has fueled a debate between two distinct "schools", concerning the factors that are responsible for these changes (e.g., Carrington & Marsh, 2005; Eshet-Alkalai & Geri, 2007; Tyner, 2003). Studies of the **usability/experience school** (e.g., Hargittai, 2005; Nielsen, 1993; Nielsen & Tahir, 2002; Shneiderman, 1998), claim that the usability and experience of users in using the technology are the main factors that are responsible for the observed differences in digital skills. On the other hand, studies of the **age/generation-gap school** (e.g. Carrington & Marsh, 2005; Prensky, 2001a; 2001b; Snyder, 2007; Tapscott, 1998) claim that age and the generation-gap between users are the main sources of these differences, arguing that hypermedia digital environments are more suitable for the flexible and non-linear thinking modes of younger people.

In order to contribute to this debate, in 2007 Eshet-Alkalai and Chajut (2009) used three matched-control groups, similar in age and demographic background to the groups of Eshet-Alkalai and Amichai-Hamburger (2004) (i.e., High-School students, College students, and adults older than 30 years old). Participants in each control group were tested with tasks similar to the tasks used by Eshet-Alkalai and Amichai-Hamburger (2004) in 2002 five years earlier. Using this method Eshet-Alkalai & Chajut (2009) could distinguish between the age/generation-gap and the usability-experience as the main factors responsible for the observed changes through time in digital skills. Our two hypotheses in setting the control groups were as follows:

1. **Significant differences** in performance between the participants of the 2002 experiment group (of Eshet-Alkalai & Amichai-Hamburger, 2004) and their matched control group (users of the same age and demographic background tested in 2007), would indicate that experience/usability was the major factor underlying the observed differences in digital skills. For example, if a 30-year old participant from the control group of 2007 performed **significantly better** than another 30-year old participant of the same demographic background from the experiment group of 2002, this would indicate that the age of participants doesn't explain the observed differences in digital skills and that the experience of users in using digital technologies is the major factor underlying the observed differences.
2. **No Significant differences** in performance between the participants of 2002 and their matched control group (users of the same age, tested in 2007) would indicate that age/generation-gap was the major factor underlying the observed differences in digital skills. For example, if the performance of a 30-year old participant from the control group of 2007 was **not significantly different** than another 30-year old participant of the same demographic background from the experiment group of 2002 (Eshet-Alkalay & Amichai-Hamburger 2004), this would indicate that the usability and experience of participants with the technologies cannot explain the observed differences in digital skills and that age/generation-gap should be regarded as the main factor responsible for the observed differences.

A comparison of the performance of each age-group from 2002 with the performance of the matched control group in 2007 (Figure 1) shows significant differences between the two groups in all the tasks (except for the performance of the college students in the reproduction task). This pattern of results suggests that the usability and the experience of users with the technology are the factors responsible for the observed changes over time in digital literacy skills.

Discussion

Results from the various digital literacy experiments clearly show that digital literacy skills change significantly over time, that they are not equally shared among all age-groups, and that the commonly-held notion that the younger generation is more digitally-literate than older technology users (Tapscott, 1998) should be examined with care. In light of the numerous reports in the literature regarding the low level of digital literacy among users (e.g., Ba et al., 2002), our findings illustrate the potential of using an existing model of digital literacy for tracing long-range changes in digital skills among users. In the following paragraphs, the findings are discussed from two different points of view:

Experience or age: In order to contribute to the debate on whether the reported changes in digital literacy skills over time (Figure 1) are related to age or to the experience with technology gained through time, we compared (Figure 1) the participants' scores in 2002 (data from Eshet-Alkalai & Amichai-Hamburger, 2004) with the scores of the control groups of 2007 (data from Eshet-Alkalai & Chajut, 2009), assuming that a significant difference between the two groups will suggest that the **usability or experience** of users with technology accounts for the observed changes over time in digital literacy skills, whereas minor or absent differences will indicate that **age or generation-gap** accounts for these changes.

Analysis of the differences between each age-group in 2002 and the equivalent control group in 2007 reveals a significant difference for all age-groups and in most literacy skills. This clearly suggests that **experience** with technology is responsible for the changes over time in digital literacy skills, regardless of their age.

The digital skills gap - you can teach old dogs new tricks: Eshet-Alkalai and Amichai-Hamburger (2004) found significant differences in the performance of users from the different age-groups; the younger participants (high school students) performed significantly better than the older participants (30-40 years old) in the photo-visual and the branching literacy tasks, whereas the older participants performed significantly better in the reproduction and information literacy tasks. Eshet-Alkalay and Chajut (2009) found that, five years later, the performance of the same participants had changed significantly: The older participants improved significantly in the tasks that emphasize experience and technical control, such as photo-visual and branching literacy tasks (Hargittai, 2005), whereas, the performance of the younger participants improved only moderately in these tasks. Consequently, although the younger participants still performed better than the older ones in these literacy skills, the performance of the two groups became almost equal and the gap between them decreased dramatically.

On the other hand, for the tasks that emphasized creativity and critical thinking, such as the reproduction and the information literacy tasks (Hargittai, 2005; Eshet-Alkalai & Geri, 2007), the performance of the younger participants decreased significantly, whereas the adults improved slightly. Consequently, the gap between the younger and the older participants, which already existed in 2002 (Eshet-Alkalai & Amichai-Hamburger, 2004), widened in favor of the adults. In other words, results indicate a closing of the gap between young and old for the experience-technical skills and a widening of the gap for the critical-creativity skills during the 5-year period from 2002 to 2007.

We suggest that these changes over time in digital literacy skills reflect the experience of using technology in everyday life, gained by the older population during the past years (Bureau of Labor Statistics, 2008). On the other hand, we suggest that the observed decrease in the more creative and critically-demanding skills (i.e., reproduction and information skills), especially among the younger participants, may result from the lack of sufficient cognitive tools for making sophisticated use of digital technologies.

The results discussed here have some important implications for educators and developers of digital environments. The large-scale improvement of the adult group in skills that require technical control (i.e., photo-visual and branching) illustrates the great potential for experience and training in improving users' performance with digital technologies. On the other hand, for the more critical and creative skills (i.e., reproduction and information), experience and exposure to information can have a negative effect on the users' performance, as illustrated by the observed significant decrease over time among the young participants. The drastic decrease in information literacy skills may also point to possible negative effects of "information flooding" on information consumers, as pointed out by Marcum (2002), Bruce (2003), Tenner (2006) and Eshet-Alkalai & Geri (2007), suggesting that the exposure of consumers to large volumes of information may eventually lead to a decrease in their ability to think critically about the information. Both Eshet-Alkalai (2008a) and Tenner (2006), claim that when "bombarded" with large volumes of information, uneducated consumers are unable to ignore the many biased and falsified pieces of information they retrieve and they fail to exercise critical thinking skills. As indicated by many studies (Ba et al., 2002; Bawden, 2001; Eshet-Alkalai, 2008b), users employ a wide variety of tactics and smart technologies (e.g., Google and Yahoo) in order to cope with the bombardment of information overload. But by doing so, are we to surrender our own information-screening skills in favour of technology-led screening? Are we witnessing a process in which we give up our human wisdom as information technologies become more "intelligent"? (Tenner, 2006). This notion should alert educators who are engaged in teaching or training computer skills and computer literacy. It is a common practice among educators and researchers to regard digital literacy as a skill of mastering the technical aspects of using computer programs or digital devices (Ba et al., 2002). From our findings, it is evident that mastering technical skills, such as using software or information-seeking, is not enough to make educated scholars and information consumers. The increasingly poorer scores of the younger participants in creative-critical skills (information and reproduction), compared to their high scores in the more technical-experience skills (photo-visual and branching) suggest that mere technical control of a digital environment does not ensure educated use and that educational systems should place a stronger emphasis, especially at young ages, on developing creative and critical, rather than technical, digital skills (Eshet-Alkalai & Geri, 2007; Labbo, Reinking, & McKenna, 1998).

References

Aviram, R., & Eshet-Alkalai, Y. (2006). Towards a theory of digital literacy: Three scenarios for the next steps. *European Journal of Open Distance E-Learning.* Retrieved from http://www.eurodl.org/materials/contrib/2006/Aharon_Aviram.htm.

Ba, H., Tally, W., & Tsikalas, K. (2002). Investigating children's emerging digital literacies. *Journal of Technology, Learning and Assessment, 1*. Retrieved from http://www.jtla.org.

Bawden, D. (2001). Information and digital literacies: A review of concepts. *Journal of Documentation*, *57,* 218-259.

Benjamin, W. (1994). *The work of art in the age of technical reproduction*. [Hebrew translation from German].Tel Aviv: Teamin Publishers.

Bruce, B. C. (2003). *Literacy in the information age: Inquiries into meaning making with new technologies*. Newark, Delaware: International Reading Association.

Bureau of Labor Statistics. (2008). *American time use survey summary*. Retrieved from http://www.bls.gov/news.release/atus.nr0.htm

Carrington, V., & Marsh, J. (2005). Digital childhood and youth: New texts, new illiteracies. *Discourse, 26,* 279-285.

Eshet-Alkalai, Y. (2004). Digital literacy: A conceptual framework for survival skills in the digital era. *Journal of Educational Multimedia and Hypermedia, 13*, 93-106.

Eshet-Alkalai, Y. (2008a). Humans under bombardment. *Inroads – The SIGCSE Bulletin*, *39*(4), 57-61.

Eshet-Alkalai, Y. (2008b). Real-time thinking in the digital era. In M. Khosrow-Pour (Ed.), *Encyclopedia of information science and technology* (2nd ed.) (pp. 3219-3223). London: Idea Group Inc.

Eshet-Alkalai, Y., & Amichai-Hamburger, Y. (2004). Experiments with digital literacy. *Cyber Psychology and Behavior, 7,* 425-434.

Eshet-Alkalai, Y., & Chajut, E. (2009). Changes over time in digital literacy. *Cyber Psychology and Behavior, 12*, 713-715. doi: 10.1089=cpb.2008.0264.

Eshet-Alkalai, Y., & Geri, N. (2007). Does the medium affect the message? The influence of text representation format on critical thinking. *Human Systems Management, 26,* 269-279.

Eshet-Alkalai, Y., & Geri, N. (2009). Congruent versus incongruent display: The effect of page layout on critical reading in print and digital formats. In Y. Eshet, A. Caspi, S. Eden, N. Geri & Y. Yair (Eds.), *Learning in the Technological Era IV: Proceedings of the 2009 Chais Conference*, 18.2. 2009, Raanana, The Open University of Israel, pp. 73-80.

Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education*, *2*, 85–105.

Hargittai, E. (2002). Beyond logs and surveys: In-depth measures of people's web use skills. *Journal of the American Society for Information Science and Technology, 53,* 1239-1244.

Hargittai, E. (2005). Survey measures of web-oriented digital literacy. *Social Science Computer Review, 23,* 371-379.

Labbo, L. D., Reinking, D., & McKenna M. C. (1998). Technology and literacy education in the next century: Exploring the connection between work and schooling. *Peabody Journal of Education, 73,* 273–289.

Marcum, J. J.W. (2002). Rethinking information literacy. *Library Quarterly, 72,* 1-26.

Marsh, J. M. (2005). *Popular culture, new media and digital literacy in early childhood*. NY: Routledge.

Nielsen, J. (1993). *Usability engineering*. San Diego: Morgan Kaufman.

Nielsen, J., & Tahir, M. (2002). *Homepage usability*. New York: New Riders Publishing.

Prensky, M. (2001a). Digital natives, digital immigrants. *On the Horizon*, 9. Retrieved from http://pre2005.flexiblelearning.net.au/projects/resources/Digital_Natives_Digital_Immigrants.pdf.

Prensky, M. (2001b). Listen to the natives. *Educational Leadership*, *63,* 8-13.

Shneiderman, B. (1998). *Designing the user interface*. New York: Addison Wesley.

Snyder, I. (2007). Literacy, learning and technology studies. In R. W. Haythornthwaite (Ed.). *The Sage handbook of e-learning research* (pp. 394-415). London: Sage Publications.

Spiro, R. J., Feltovitch, P. L., Jacobson, M. J., & Coulson, R. L. (1991). Cognitive flexibility, constructivism and hypertext: Random access instruction for advanced knowledge acquisition in ill-structured domains. *Educational Technology, 31,* 24-33.

Tapscott, D. (1998). *Growing up digital*. New York: McGraw-Hill.

Tenner, E. (2006, March 26). Searching for dummies. New York Times. Retrieved from http://www.nytimes.com/2006/03/26/opinion/26tenner.html

Tuft, E.R. (1990). *Envisioning information*. Cheshire, CT: Graphic Press.

Tyner, K. (2003). Beyond boxes and wires: Literacy in transition. *Television & New Media, 4,* 371-388.

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