Re-Imaging Learning Environments
Proceedings of the European Distance and E-Learning Network 2016 Annual Conference
Budapest, 14-17 June, 2016
ISBN 978-615-5511-10-3
ISSN: 2707-2819
doi: https://doi.org/10.38069/edenconf-2016-ac-0001

AN INVITATION TO LOOK AT ENHANCEMENT IN TECHNOLOGY-ENHANCED LEARNING

Stéphanie Gauttier, Inmaculada Arnedillo-Sanchez, Trinity College Dublin, Ireland

The Internet, e-learning and now mobile learning are seen as opportunities for individual to access information and engage in learning anytime, anywhere. However, digital devices and technologies are also perceived as detrimental for learning (Dror, 2007), memory and attention (Watson, 2015). The role that they play in learning needs questioning.

Technology-enhanced learning (TEL) is the use of technologies for learning. The term appears almost systematically in research concerned with e-learning without being discussed in itself (Kirkwood & Price, 2014). To this end, there is a call for drawing more attention to the concept of enhancement, which is at the core of TEL, (Kirkwood & Price, 2014; Dror, 2008).

This paper proposes a discussion of the notion of Technology-Enhanced learning. Firstly, it will examine the definition of enhancement and highlight how learners could be cognitively enhanced. Secondly, it will discuss the role of technology in learning as seen in literature, and illustrate it mainly performs an enabling function, rather than an enhancing one. The paper argues that technology appears to have a real enhancing role when the cognitive abilities of the learner are taken into account. Based on these considerations, future research directions for TEL will be proposed.

Enhancement as a person-centred concept

This section introduces the concept of enhancement as person-centred event. It discusses the definition of enhancement as extended abilities for the individual, which can be reached by intervention on competencies, mood and performance. To achieve this, the person can be enhanced in a physical or cognitive manner. This work focused on cognitive enhancement and present different means to achieve it, among which technology.

The transhumanist movement defines enhancement as a way to extend intellectual, physical and psychological abilities of individuals, so that they can go beyond their naturally limited capacities to become transhumans (More, 2013). For transhumanists, enhancement is not about repairing disabilities and relieving individuals from suffering, but going beyond the realm of what we know as possible, in a quest for happiness (Bailey, 2013; Bostrom, 2005). As such, it has a transformative impact on the individual and aims to increase the capacities, the efficiency of individuals.

To extend the abilities of the person beyond possible, enhancement can have three objects: (a) the competencies of a person; (b) the state (mood) of a person; (c) the performance of a person. The realization of at least one of them is enough to enhance the individual (Baertschi, 2011). Baertschi (2011) establishes a link between the duration of enhancement and its impact: if one takes amphetamines before an exam, it's to enhance performance at a given moment. If one takes drugs regularly to increase one's attention, then it's to enhance a capacity or competency.

Types of enhancement and ways to achieve it

Competencies, moods and performance can be enhanced by intervening on the physical or cognitive abilities of the individual. Physical enhancement entails gaining new bodily capacities, for instance through addition of new limbs, and improving body resistance to achieve a radical extension of human health span and life expectancy. Cognitive enhancement instead is "the amplification or extension of core capacities of the mind through improvement or augmentation of internal or external information processing systems" (Bostrom & Sandberg, 2009). Enhancing cognition refers to "the processes an organism uses to organize information. This includes acquiring information (perception), selecting (attention), representing (understanding) and retaining (memory) information, and using it to guide behaviour (reasoning and coordination of motor outputs)", (Bostrom & Sandberg, 2009). To this end, three types of cognitive enhancement can be identified in relation to enhancing performance: (a) Enhancing separate cognitive processes; (b) Enhancing the process overall; (c) transforming the hierarchy of processes to make it more efficient. Similarly, it can have different objectives. For instance, enhancing the performance of the individual for a specific task at a specific moment, or enhance the cognitive abilities of the individual overall. Furthermore, aspects of physical and cognitive enhancement overlap as cognition is bodily-based. Notwithstanding the role of the body and perceptual senses in learning, the focus of this work is on cognitive enhancement (CE). Cognition, from the Latin *cognoscere*, which means to know. Thus, the processes which help individuals to learn, gain knowledge and skills, are the ones to be considered here.

Cognitive enhancement can be achieved through different means such as pharmaceutical, neurological, genetic therapy or technology. Pharmaceuticals like nootropics (neuro-enhancers) can be used and for instance, pills to increase memory or attention are available on the market. Through non-invasive neurological techniques such as brain stimulation and brain-machine interfaces, or through invasive techniques as neural implants, neuro-enhancement can be achieved. Also, gene therapy can be used to modify some traits hereditary traits or traits linked to learning. Finally, technology can be utilised to enhanced cognition. Bostrom and Sandberg (2009) outline several technological means to obtain cognitive augmentation; (a) internal software: learning improved cognitive strategies or making use of the plasticity of the brain; (b) external hardware and software: collective cortex, artificial intelligence, software agents; (c) intelligence augmentation: software, mediation "embedding the human within an augmenting shell such as wearable computers or virtual reality"; (d) smart environments. Regarding the variety of purposes involved in the use of

ISBN 978-615-5511-10-3

these technologies, Bostrom and Sandberg (2009) argue information technology can "give an overview, keep multiple items in memory, and perform routine tasks. Data mining and information visualization tools help produce overview and understanding where the perceptual system cannot handle the amount of data, while specialized tools like expert systems, symbolic math programs, decision support tools, and search agents expand specific skills and capacities". While they highlight the role technology can play in the areas of perception, understanding and application of knowledge (decision making), our work focuses on the role of technology in enhancing the learner.

Enabling versus enhancing the learner

While technology can enhance cognition and therefore learning in many ways, two different roles for technology in learning can be identified: (a) Technology as an enabler of learning whereby learners are afforded access to learning material; (b) Technology as an enhancer of learning whereby learners' capacities and performance are improved.

Technology enables, but doesn't necessarily enhance the learner

In practice, the role technology plays in enhancing learning is often implicit rather than explicitly articulated (Kirkwood & Price, 2014; Dror, 2008). To this end trends which characterize the affordances technology offers learners are:

- Provides more access to information (mainly through the Internet).
- Provides more access to education by allowing them to enrol in classes in remote places (via for instance e-learning courses and MOOCS).
- Provides more access to learning, as people can learn anywhere and anytime using their mobile devices (via m-learning).
- Provides more access to other learners and enable learners to learn by interacting with each other. For instance, mobile learning and computer-supported collaborative learning (CSCL) examines way in which learners can find each other (Kukulska-Hulme et al., 2011).
- Provides contextualized instructions. Technologies like Augmented or Virtual Reality allow learners to learn by being immersed in the environment related to their task. It allows them to practice tasks they wouldn't have the possibility to practice for real without risk (Hung et al, 2015). It allows them to learn what to do in this environment (Lee & Akin, 2011).
- Technology makes knowledge less abstract through visualization. For instance, augmented reality has been used to improve spatial abilities of learners, which are required for better understanding of geometry and mathematics (Kaufmann & Schmalstieg, 2003).

ISBN 978-615-5511-10-3

Not all these points relate to enhanced learning. Indeed, they do not all refer to learning itself. First, increased access to information doesn't mean individuals process that information in such a way that they gain new knowledge out of it. Information can be perceived, but not understood, memorized or applied. Second, contextualized or digitalized instructions may not lead to gaining skills. Indeed, it is merely about following what the technology instructs the user to do, without necessarily understanding the logic behind the instructions and steps to take. The depth of understanding is questionable. Moreover, Dror (2007) highlights that by providing too much to the learner, technology present the risk of reducing the depth of processing and memory in learners themselves.

What is related to learning here is getting more access to learning. Learners can engage in learning whenever and wherever they want, gaining flexibility. But this doesn't necessarily lead to increased efficiency, improved cognitive skills and learning.

The second point related to learning is the way knowledge is made less abstract by the means of visualization techniques. This is related to improved understanding, and in turn better learning.

To summarize technology would have an enabling role – it enables access to learning, information, and enables users to perform specific tasks – and an enhancing role, linked to improved understanding of concepts.

Technology enables the learner when it looks at cognitive processes and performance

We will discuss what has been identified as enhancement in TEL research and show that even though enhancement has not been a core concern so far, there is literature documenting improved cognitive processes and learners' performance.

Kirkwood and Price (2014) conducted a literature review on TEL. They highlight that the type of enhancement to be offered through the technology is not intentionally stated in the work. A posteriori analyses allows to highlight 8 ways in which enhancement can be conceived in TEL: (a) increased flexibility, (b) improved retention (memory), (c) improved engagement or time spent on a learning task, (d) more favourable perception or attitudes, (e) improvement in test and assessments, (f) deeper understanding, (g) more reflexion or critical awareness, (h) improved interaction online and sharing experiences.

These aspects of enhancement overlap with the cognitive processes transhumanists describe. For instance, memory and understanding can be improved. Improvement in assessment also denotes of increased learning efficiency.

But there are also aspects that do not necessarily relate to enhancement. Indeed, there is little to no evidence that increased flexibility, engagement, attitude, and increased interaction translate in better learning outcomes. Kirkwood and Price (2014) underline that while current

ISBN 978-615-5511-10-3

literature uses "quantitative measures that may be easy to capture, they contribute little to no understanding how (…) can promote qualitative developments in learning".

We are facing a double issue here. First, cognitive processes have a direct impact on learning outcomes, and thinking of how to enhance them is de facto linked to enhancing learning, while some other variables such as participation, flexibility, may have an indirect impact on learning outcomes and efficiency. Second, the evidence used in TEL literature is not always conclusive. Because enhancement is not intentionally designed, evaluations use sets of measure that are not efficient in proving enhancement itself. There needs to be more reflexion around TEL at technology design and evaluation stages.

Directions for further developments

This section opens up directions for TEL research. We discuss how cognitive enhancement can be integrated to technology design processes. As enhancement is not neutral on the individual, risks have to be considered.

Need to integrate intended enhancement to technology design

Enhancement must be integrated to technology-design processes. Xia and Maes (2012) propose a framework for designing intelligence augmentation. They suggest considering the desired state after enhancement, the processes at stake for the tasks, can the role of the technology on the processes (or hierarchy of processes).

Although this approach can serve as a roadmap, there is still a lack of guidelines on what is to be enhanced and how to approach that decision. Indeed, in a specific situation, being able to forget something might be an enhancement, while in others enhancement may come in the form of better memorization, for instance. For design to integrate enhancement, there must be clarity in the impact sought, but also on the time-frame of that impact. Is the artefact impact memory for a specific moment, or is it touching to memory as the overall ability of the learner?

Another challenge is linked to understanding the type of enhancement needed by different learners – adults and children are at different developmental stages and face different cognitive challenges.

The setting in which learning is occurring, and the presence of a teacher might influence ways to improve learning. The depth of learning looked for, depth of understanding, has be accounted for.

Finally, the learner's familiarity with the task or learning topic will have an impact on the enhancement needed from the technology to improve his/her performance.

There is so far little understanding of the impact these different variables would have on designing enhancement and no guidelines in terms of technological affordances, features, that

ISBN 978-615-5511-10-3

would be needed to enhance learners. There's also very little understanding of how to assess the efficiency of technologies regarding their enhancing character.

Need to develop thinking about how we assess artefacts for TEL

Evaluations of TEL present three types of shortcomings, which might hide the risks involved in using technology to intervene on cognitive processes.

First, as mentioned above, evidence collected during evaluation of technologies for learning and learners' assessment is often not appropriate from an enhancement perspective. Reflexion around the meaning of increased learning efficiency has to be carried out. Dror (2008) underlines that "too often 'learning' is reduced and limited to acquisition of information", whereby efficiency equals the number of things learnt. But the notion of efficiency linked to enhancement has also been discussed concerning intelligence augmentation as allowing to comprehend/solve problems better, faster and in new ways. A technology-enhanced learner would have to learn "better" (quality of learning), faster, and be able to apply knowledge to do new things (Engelbart, 1962).

Second, evaluations do not consider long-term persistence of learning outcomes (Kirkwood & Price, 2014). Evaluations occur right after technology usage. At best, short term memory is tested. But there is no evidence of TEL systems allowing users to get better memory long-term, knowledge and understanding of the concepts a while after discovering them with technology.

Thirdly, the impact of technology use on cognitive processes over time hasn't been a concern so far. However, Dror (2008) underlines that the loss of devices is lived as the loss of one's own cognitive capacities and (Dror, 2007) that by providing too much to the learner, technology presents the risk of reducing the depth of processing and memory in learners themselves. This would in turn create a need for enhancement and lead users to use even more technology, as a consequence of being diminished by the technology.

Besides what is perceived consciously by the learner, some developmental processes can be at stake. Indeed, using technologies changes the way we develop by modifying our physical activity and the structure of our brains. These changes could hinder or even prevent some developmental stages as we know them today – if kids do not develop precise locomotor skills because they learn through tablets instead of playing with smaller toys, will they be able to acquire the same precision of movement that we can now have? Will it have an impact on their cognitive abilities overall? Without calling for a precautionary or proactivity principle, we argue that enhancement and its potential downsides must be considered by developers for more ethical technology development.

ISBN 978-615-5511-10-3

Conclusion

Enhancement for learners resides mainly in cognitive enhancement, that is increased efficiency of cognitive processes such as perception, attention, memorization, understanding or applying knowledge. By improving one or several processes, one improves the learning outcomes for the learner. TEL literature highlights affordances from technology for learners, such as access to information, other learners, education, which are enabling learners. It also identifies some areas of enhancement, linked to cognitive processes but also to variables more indirectly related to learning efficiency. Enhancement has to be considered at a technology-design design stage for TEL to be effective, and to allow better assessment. An important downside of enhancement is the impact that enhancing one skill has on parallel or depending cognitive skills which development could be impaired, and the enhancement of the learner overall through time. Transdisciplinary research bridging such disciplines as learning, cognitive sciences and neurology is needed to illuminate the impact of enhancement technologies on the brain and learning overall. Studies that consider enhancement in a longitudinal perspective are required to guide educational practices and leverage the power of technology at the most.

References

1. Baertschi, B. (2011). Chapitre 4. L'humanité se dit de multiples manières. *Journal International de Bioéthique, 22*, 67–76.
2. Bailey, R. (2013). For Enhancing People. In M. More & N. Vita-More (Eds.), The Transhumanist Reader: Classical and Contemporary Essays on the Science, Technology, and Philosophy of the Human Future, (pp. 327-344). Oxford: John Wiley & Sons.
3. Bostrom, N. (2005). A history of transhumanist thought. *Journal of Evolution and Technology, 14*(1), 1-25.
4. Bostrom, N., & Sandberg, A. (2009). Cognitive enhancement: methods, ethics, regulatory challenges. *Science and Engineering Ethics, 15*(3), 311-341.
5. Collins, A., Greeno, J., Resnick, L. B., Berliner, B., & Calfee, R. (1992). Cognition and learning. In B. Berliner & R. Calfee (Eds.), *Handbook of Educational Psychology*. New York: Simon & Shuster MacMillan
6. Engelbart, D. C. (1962). *Augmenting Human Intellect: A Conceptual Framework.* Doug Engelbart Institute, SRI Summary Report AFOSR-3223 • Prepared for: Director of Information Sciences, Air Force Office of Scientific Research, Washington DC, Contract AF 49(638)-1024 • SRI Project No. 3578 (AUGMENT, 3906). Retrieved from http://www.dougengelbart.org/pubs/augment-3906.html
7. Dror, I. E. (Ed.). (2007). *Cognitive technologies and the pragmatics of cognition* (Vol. 12). John Benjamins Publishing.
8. Dror, I. E. (2008). Technology enhanced learning: The good, the bad, and the ugly. *Pragmatics & Cognition, 16*(2), 215-223.

9. Hannafin, M. J., & Land, S. M. (1997). The foundations and assumptions of technology-enhanced student-centered learning environments. *Instructional science, 25*(3), 167-202.
10. Hung, A. J., Shah, S. H., Dalag, L., Shin, D., & Gill, I. S. (2015). Development and validation of a novel robotic procedure specific simulation platform: partial nephrectomy. *The Journal of urology, 194*(2), 520-526.
11. Kaufmann, H., & Schmalstieg, D. (2003). Mathematics and geometry education with collaborative augmented reality. *Computers & Graphics, 27*(3), 339-345.
12. Kirkwood, A., & Price, L. (2014). Technology-enhanced learning and teaching in higher education: what is 'enhanced' and how do we know? *A critical literature review. Learning, media and technology, 39*(1), 6-36.
13. Kok, A. (2009). Understanding the Technology Enhanced Learning Environments from A Cognitive Perspective. *International Education Studies, 2*(4), 3.
14. Kukulska-Hulme, A., Sharples, M., Milrad, M., Arnedillo-Sánchez, I., & Vavoula, G. (2011). The genesis and development of mobile learning in Europe. In D. Parsons (Ed.), *Combining E-Learning and M-Learning: New Applications of Blended Educational Resources,* (pp. 151-177). Hershey, PA: Information Science Reference. ISBN: 978-1-60960-481-3.
15. Lee, S., & Akin, Ö. (2011). Augmented reality-based computational fieldwork support for equipment operations and maintenance. *Automation in Construction, 20*(4), 338-352.
16. More, M. (2013). The Philosophy of Transhumanism. In M. More & N. Vita-More (Eds.), *The Transhumanist Reader: Classical and Contemporary Essays on the Science, Technology, and Philosophy of the Human Future*, (pp. 3-17). Oxford: John Wiley & Sons. doi: 10.1002/9781118555927.ch1
17. Watson, L. (2015, May 15). Humans have shorter attention span than goldfish, thanks to smartphones. The Telegraph [blog]. Retrieved from http://www.telegraph.co.uk/news/science/science-news/11607315/Humans-have-shorter-attention-span-than-goldfish-thanks-to-smartphones.html
18. Xia, C., & Maes, P. (2013). The design of artifacts for augmenting intellect. In *Proceedings of the 4th Augmented Human International Conference,* (pp. 154-161). ACM.

Acknowledgements

Financial support of the Eduworks Marie Curie Initial Training Network Project (PITN-GA-2013-608311) of the European Commission's 7th Framework Programme is gratefully acknowledged.