Michal Klichowski

Learning in cyberparks

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WYDAWNICTWO NAUKOWE UAM

Learning in CyberParks

ADAM MICKIEWICZ UNIVERSITY IN POZNAN

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Michal Klichowski

Learning in CyberParks

A theoretical and empirical study

WYDAWNICTWO NAUKOWE

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The theoretical part of the book shows that learning in CyberParks takes the form of technology-enhanced outdoor learning and is an element of smart learning, i.e. the latest concept of ICT-supported learning. Learning in CyberParks can also become an element of smart education – a concept of formal learning in the smart city. Learning in CyberParks is supposed to provide students with contact with nature and stimulate them to be physically active. It is thus a type of a dual-task. Studies in cognitive neuroscience suggest that this type of cognitive-motor interference can expose students to a motor danger and weaken their cognitive capabilities. If this was the case, the idea of learning in CyberParks would need to be modified. In order to solve this, two experiments with the use of mobile EEG were carried out. The empirical part of the book indeed shows that during dual-tasks in CyberParks students are less focused and more stressed, and the dynamics of attention and meditation ceases to reflect the dynamics of the cognitive task. Thus, before CyberParks become learning spaces, the idea of CyberParks has to be modified. The cognitive activity intended in CyberParks should be separated from physical activity. When learning in CyberParks, one should be sitting and using applications that do not require movement. Staying close to nature improves the functioning of the brain, therefore such learning is more effective than that carried out indoors. It is also more healthy. When designing CyberParks, one thus has to think not only about the technological infrastructure, but also about making spots for using ICT while sitting available. In this approach, learning in CyberParks becomes an important concept that can be used in practice in order to provide an answer to numerous problems of contemporary educational institutions, related to students' lack of contact with nature and consolidation of their sedentary lifestyle.

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The more high-tech schools become,
the more nature they need.

RICHARD LOUV

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Foreword

Michal Klichowski's work opens a fascinating and stimulating read for scholars and researchers beyond the field of education, since it delivers a sound theoretical framework validated by empirical studies on learning in digitally mediated public open spaces. The insights will also prove extremely interesting for practitioners and decision-makers in urban planning and design as well as for anthropologists and social scientists concerned about the spaces and places. Learning in CyberParks, as Michael Klichowski teaches us, can also become an element of smart education, as a concept of formal learning in the smart city. Smart city though cannot rely only on technology, it has to take *people* at its core. More and more scholars and practitioners emphasise the importance of people-oriented aspects in a fast-growing ubiquitous technology, stressing the need to increase the liveability of cities. Well educated people can to make the most of knowledge and be better prepared to face a technology driven development.

This highly illuminating book marks a significant stage in growing our understanding of how digital technology development is affecting people's relations among themselves and with their environment. It also proves that spending more time outside, exposed to weather and to nature is a stimulating learning environment and can push people to be physically and mentally more active, enabling them to acquire new knowledge and skills. I take a sentence of the book "Staying close to nature improves the functioning of the brain, therefore such learning is more effective than that carried out indoors", which for me, being a passionate landscape architect hits the jackpot. From my engineering background and cooperation in several research projects for increasing resilience and sustainability of urban-ecological systems, many founded by European Union programmes, I learned that there were evidences that public and green spaces bring benefits for cities and citizens, that being more outdoors is also healthier, but these evidences were not related to benefits of education, that students in outdoors learning environments are more focused and less stressed, that being in contact with nature improve concentration and sharpens their thinking and creativity. All this brings us to a commonplace in urban planning, the more we know about the public spaces, the needs of people and the benefits of a healthy and inspiring environment, the better strategies and programmes can be designed. To learn and live in healthy environment are basic needs and much is known about, how we learn and what are the benefits of spending time outdoors. However, very few is known about these in meditated spaces. Technology is without doubt transforming society in different ways, both good and bad, and its increasing pervasiveness has become a reality no one can ignore. Therefore, advancing knowledge on an unexplored issue as learning in mediated spaces, aptly named CyberParks, breaks new ground. Learning in CyberParks is even more difficult as very few is known about the penetration of technology in urban spaces – an issue tackled by the Project CyberParks. In this context it is worth to highlight that public spaces, as gardens and parks, are for many urban dwellers the only possible place they can contact nature.

The contact to nature is a possible answer to numerous problems of contemporary educational institutions, as Michal Klichowski says. This is an interesting line of thought, as the intertwining of real and virtual worlds opens new ways for citizens to appropriate and get attached to urban spaces. The CyberParks Project, which provides the backdrop for this book, is founded by the European Cooperation in Science and Technology (COST). As a network, CyberParks opens up opportunities for participants to gather and explore, from different viewpoints, the emerging challenge that digital technology advancements and their increasing pervasiveness pose to the production and use of urban spaces. Interdisciplinary cooperation is particularly important in the light of the opportunities technology can open for making urban spaces more inclusive and to better understand the socio-cultural, spatial, and technological factors as well as their interactions, in order to provide arguments for decision-making processes towards improving urban liveability and democratic processes.

In the context of CyberParks, I got to know and appreciate the work of Michal Klichowski: He accepted a vague idea of what a CyberPark and the "digital mesh" can be, and building on this vagueness developed such body of research on smart learning. The research made for his book provides on the side, evidences that multidisciplinarity and interdisciplinarity going over the edge of single disciplines meld ideas and boost cross-pollination, paving the way for advancing comprehensive knowledge and opening new research prospects. Although different disciplines share similar underlying motivations, each has different emphases and proposes different conceptual understandings and frameworks. But the chief outcome is that they add value to public spaces, and as discussed, this book shed light on their socio-educational benefits. The results here discussed, by integrating knowledge and methods from different disciplines, provide an intrinsic and holistic perspective for learning studies, neurosciences and digital technologies. Along with the practical measures towards provoking critical reflection about outdoor learning and the environments used for it, Michal Klichowski adds further weight to the call on the quality of public spaces, which remains a central issue, even in the digital era. As long as the public spaces are not accessible, safe and placed in the core where people live, all knowledge on the benefits remain useless. No one will leave their home and use a public space, if it isn't safe or doesn't meet the needed requirements.

I wish that this book will find a broad audience not only among education experts, as readers from other backgrounds will benefit from the knowledge gleaned for this volume. This book is a step forwards to achieving the aims of CyberParks: to increase multidisciplinary understanding of public spaces and to celebrate publicness, as in the end an enliven public space makes up the richness of urban life. Building *digital* bridges calls for experts who can face the challenge of a continually evolving society, what Michal Klichowski mastered perfectly with his pioneering book.

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This study is a part of a greater project supported by the European Cooperation in Science and Technology: *Fostering knowledge about the relationship between Information and Communication Technologies and Public Spaces supported by strategies to improve their use and attractiveness (CYBERPARKS)* (TUD COST Action TU1306). I would therefore like to thank all those whom I co-operated with when working on this project. In particular, I would like to give special thanks to its leaders, Professors Carlos Smaniotto Costa (Management Committee Chair; Lusofona University of Humanities and Technologies, Portugal), Ina Suklje Erjavec (Management Committee Vice Chair; Urban Planning Institute of the Republic of Slovenia, Slovenia), and Michiel de Lange (Working Group 3 Leader; Utrecht University, Netherlands). I am also thankful to all my colleagues in the project that I worked together with on our articles and with whom I discussed CyberParks, as well as talked about life and academic work in different European cities. My special thanks go to Professor Philip Bonanno (University of Malta, Malta), who was the first person I know that got interested in learning in CyberParks and with whom I could co-create the Learning in Technology-Enhanced Open Spaces Task Group (LITEOS), and Professor Catarina Patricio (Lusofona University of Humanities and Technologies, Portugal), with whom I wrote my favourite paper about CyberParks, as well as Professors Konstantinos Ioannidis (University of Stavanger, Norway), Jose Diogo Mateus (Lusofona University of Humanities and Technologies, Portugal), Tiago Duarte (also Lusofona University of Humanities and Technologies, Portugal), Marluci Menezes (National Laboratory for Civil Engineering, Portugal), Antoine Zammit (University of Malta, Malta), Thanos Vlastos (National Technical University of Athens, Greece), Alfonso Bahillo (University of Deusto, Spain), Francisco Klauser (University of Neuchatel, Switzerland), Catherine Woods (Dublin City University, Ireland), and Christoph Breser (University of Technology Graz, Austria) and Kai Dolata (Urbikon, Germany).

The European Cooperation in Science and Technology does not finance the equipment necessary to carry out research. It would not have been possible to conduct the experiments described in this book without other financial resources. In order to purchase the equipment, I used a part of the resources from the scholarship for young outstanding scientists funded by the Ministry of Science and Higher Education in Poland (0049/E-336/STYP/11/2016). It would not have been possible to receive this highest and most prestigious scholarship that is awarded to young Polish researchers had it not been for the support of my academic tutors from the Faculty of Educational Studies (Adam Mickiewicz University in Poznan, Poland), Professors Hanna Krauze-Sikorska, Kinga Kuszak and Jacek Pyzalski, whom I would like to thank very much at this point. I am also thankful to Professor Gregory Kroliczak from the Institute of Psychology (Adam Mickiewicz University in Poznan, Poland), who has been introducing me to the world of cognitive neuroscience with great patience.

I would also like to express my thanks to my brother-in-law and wonderful friend, Marcin Jaskulski, who has never spared any effort to support me with his IT skills every time I design new research tools, as was the case as far as applications used in the experiments described in this book are concerned.

I am also thankful to my reviewers, Professors Vitor Duarte Teodoro (Nova University of Lisbon, Portugal) and Zbyszko Melosik (Adam Mickiewicz University in Poznan, Poland), for their constructive feedback on this book, and the authorities at the Faculty of Educational Studies (Adam Mickiewicz University in Poznan, Poland), in particular Professors Agnieszka Cybal-Michalska and Waldemar Segiet, for their help to publish the book.

The book was written under very specific conditions, i.e. at a time when very little was known on the topic of CyberParks, and completely nothing was known on the topic of learning in them. As a result, the theoretical analyses undertaken were research analyses themselves for me, based on the latest and interdisciplinary scientific reports. All these reports (see References) are written in English, and therefore it is the language this book has been written in. This is a standard in contemporary research, which makes communication among all the researchers in the world possible. Nevertheless, when I was analysing the concepts of technology-enhanced learning and outdoor learning, many times I recalled the information that during my studies I used to find in Polish publications. As this point, I would thus like to thank all Polish researchers who lived in Poland under different social and political conditions, and wrote in Polish only. I do remember that it was your work that shaped me.

Writing this book meant travelling across Europe. On all those trips, I was always accompanied by my wife, Anna Klichowska, who was always enthusiastic about yet another and even longer time away. I am very grateful for this support of yours. Without you, and without your faith in me, I would have never found the courage to work the way I do now, and the way I have always dreamt of doing it.

General introduction and background

Without doubt, learning is one of the most important and primordial skills of the man[1]. Through learning, the man in a way stores (and then orders) the knowledge and skills in their brain. What is more, new elements stored in the brain not only serve for further activities of the man, but – as indicated by the latest research results with the use of the resting state functional Magnetic Resonance Imaging (resting state fMRI) method – they also change the default network of their brain[2], thus, most generally speaking, they influence the basic structures of the human thought[3]. As noticed by Kean[4], the cases of people who lost the ability to learn quoted by neuropsychological reports are thus among the saddest of human stories. Not only did those individuals lose their

1. M. Heimann, T. Tjus & K. Strid, Attention in cognition and early learning. In. P. Peterson, E. Baker & B. McGaw (Eds.), *International encyclopedia of education* (pp. 165-171). Amsterdam – Boston – Heidelberg – London – New York – Oxford – Paris – San Diego – – San Francisco – Singapore – Sydney – Tokyo: Academic Press (2010).
2. J. Zsuga, K. Biro, C. Papp, G. Tajti & R. Gesztelyi, The "proactive" model of learning: integrative framework for model-free and model-based reinforcement learning utilizing the associative learning-based proactive brain concept. *Behavioral Neuroscience, **130***, pp. 6-18 (2016).
3. G. Hesselmann, C.A. Kell, E. Eger & A. Kleinschmidt, Spontaneous local variations in ongoing neural activity bias perceptual decisions. *Proceedings of the National Academy of Sciences*, ***105***, pp. 10984-10989 (2008); G. Deco, V.K. Jirsa & A.R. McIntosh, Emerging concepts for the dynamical organization of resting-state activity in the brain. *Nature Reviews Neuroscience*, ***12***, pp. 43-56 (2011); G. Deco, A. Ponce-Alvarez, D. Mantini, G.L. Romani, P. Hagmann & M. Corbetta, Resting-state functional connectivity emerges from structurally and dynamically shaped slow linear fluctuations. *Journal of Neuroscience*, ***33***, pp. 11239-11252 (2013).
4. S. Kean, *The tale of the dueling neurosurgeons: the history of the human brain as revealed by true stories of trauma, madness, and recovery*. New York: Little, Brown and Company (2014).

ability to acquire new knowledge and skills, but they also lost the chance to, metaphorically speaking, change anything in their own mind (change their own functioning through new experience). Thus the forerunners of cognitive psychology such as Bartlett noticed that there is more to learning than just acquiring knowledge and skills[5]. It was already them who observed that to learn (consciously and intentionally or unconsciously and unintentionally) is to modify oneself[6].

At present we can talk of a certain type of explosion of knowledge on learning. Above all, this is caused by the development of neurosciences, linked to the creation of (non-invasive) methods of examining the human brain in the recent years[7]. Thanks to them – as noted by Schunk[8] – learning started to be researched not just from the perspective of psychology (cognitive psychology in particular), but also neurosciences (including the key cognitive neuroscience). Bransford, Barron, Pea, Meltzoff, Kuhl, Bell, Stevens, Schwartz, Vye, Reeves, Roschelle and Sabelli[9] observe that neuroscience "measures reveal the internal mechanisms and biological substrates of learning, and this enriches our understanding of how learning occurs [...] provide useful information about the temporal unfolding and spatial location of the brain mechanisms involved in learning", as well as it helps to "understand individual differences in learning".

What is more, research into learning is also stimulated by technological development to a large extent. On the one hand, technological advancement makes it possible to conduct research into more and more advanced learning

5. C. Ranganath, A.L. Libby & L. Wong, Human learning and memory. In: K. Frankish & W. Ramsey (Eds.), *The Cambridge handbook of cognitive science* (pp. 124-125). Cambridge – New York – Melbourne – Madrid – Cape Town – Singapore – Sao Paulo – Delhi – Mexico City: Cambridge University Press (2012).
6. M.W. Eysenck & M.T. Keane, *Cognitive psychology: a student's handbook*. London – New York: Psychology Press, pp. 207-208 (2015).
7. R. Michalak, Individualization as the fundamental principle of educational proceedings. The neurocognitive perspective. *Journal of Gender and Power*, **7**, pp. 49-50 (2017).
8. D.H. Schunk, Theories of learning. In: D.C. Phillips (Ed.), *Encyclopedia of educational theory and philosophy* (p. 469). Los Angeles – London –New Delhi – Singapore – Washington DC: SAGE Reference (2014).
9. J.D. Bransford, B. Barron, R.D. Pea, A. Meltzoff, P. Kuhl, P. Bell, R. Stevens, D.L. Schwartz, N. Vye, B. Reeves, J. Roschelle & N.H. Sabelli, Foundations and opportunities for an interdisciplinary science of learning. In: Sawyer, R.K. (Ed.), *The Cambridge handbook of the learning sciences* (p. 20). Cambridge – New York – Melbourne – Madrid – Cape Town – Singapore – Sao Paulo: Cambridge University Press (2005).

machines (or maybe rather algorithms) that simulate human learning[10]; on the other, however, the widespread and mobile character of technological solutions encourages one to seek strategies for supporting learning by the man with technology[11]. The latter – as noticed by Topol[12] – has a relatively long history, yet actually it was in the recent years that a real boom has been observed in what can be called research into learning based on new technologies, and into didactics based on new technologies as well.

I can remember that when I started studying a course that combined educational studies with computer science, most of my friends did not understand what the topic of such studies can actually be. Initially, I had some problem with that myself, too. It was, however, when we actually experienced the above-mentioned explosion of knowledge on learning. I thus had an opportunity to quickly understand that learning studies, neurosciences and new technologies are interrelated. During my BA studies, I therefore tried to simulate what happens in the human brain while learning and wrote various algorithms as well as learning scripts. Later, already during my MA studies, I started to carry out research with the use of autobiographical methods, looking for how the dissemination of mobile multimedia tools influenced the dynamics of human learning. Finally, when writing my PhD thesis, I wrote my first computer program aimed to analyse human learning that allowed me to study how the immersion in the world of new technologies changes the organisation of learning in the human brain. Afterwards, already after my PhD studies, when conducting research into cyborgization, I discovered that some latest technological solutions not only just support or explain human learning but in a sense also try to lift it over the limitations of the human brain. I have thus had this pleasure to go through my entire adventure with academic work exactly in that wonderful time of the explosion of research into learning (and its dynamics in a sense reflects these times).

As stated by the already quoted Schunk[13], research into learning should be conducted in a way that would closely link them to practical measures apart

10. P. Domingos, *The master algorithm: how the quest for the ultimate learning machine will remake our world*. New York: Basic Books (2015).

11. V. Duarte Teodoro, *Modellus: learning physics with mathematical modelling*. Lisbon: Universidade Nova de Lisboa, pp. 42-48 (2002); B. Means, Prospects for transforming schools with technology-supported assessment. In: Sawyer, R.K. (Ed.), *The Cambridge handbook of the learning sciences* (pp. 505-519). Cambridge – New York – Melbourne – – Madrid – Cape Town – Singapore – Sao Paulo: Cambridge University Press (2005).

12. P. Topol, Multimedia, the Web and formal EFL exams. *Teaching English with Technology*, ***3***, p. 12 (2003)

13. D.H. Schunk, op. cit., p. 467.

from solving basic scientific issues. They should thus be easily applied in real learning situations, as well as serve to change the educational practice. Unfortunately, as shown by Edelenbosch, Kupper, Krabbendam and Broerse[14], there is an abyss between neurosciences and the practice of education. It is mainly due to the scarcity of research conducted in the cognitive neuroscience paradigms by researchers into education, and the fact that most of those researchers do not conduct interdisciplinary analyses that use the latest neuroscientific reports. The case is similar with new technologies. However, as explained by Dylak[15], the abyss between the educational practice and knowledge about technologically-supported learning at school is mainly linked to the fact that most often schools do not make the effort to implement innovative theories in their own practice. Also, educators actually very frequently demonize the new technologies themselves and perceive them as a source of numerous threats[16].

The explosion of knowledge on learning is caused by yet one more factor. As explained by Melosik[17], as well as Gromkowska-Melosik[18], the contemporary globalized world that rushes forward at a dizzying pace[19] forces the man to live in the rhythm of a continuous change, pursue fleeting categories, created by the ever-accelerating media (mostly the Internet[20]; thus, when describing

14. R. Edelenbosch, F. Kupper, L. Krabbendam & J.E.W. Broerse, Brain-based learning and educational neuroscience: boundary work. *Mind, Brain, and Education,* ***9***, pp. 40-49 (2015).
15. S. Dylak, Anticipatory education as a promising educational model for the smartphone era. In: J. Pyzalski (Ed.), *Educational and socio-cultural competences of contemporary teachers. Selected issues* (pp. 56-68). Lodz: theQ studio (2015).
16. J. Pyzalski, The digital generation gap revisited: constructive and dysfunctional patterns of social media usage. In: A. Costabile & B. Spears (Eds.), *The impact of technology on relationships in educational settings* (pp. 91-101). New York: Routledge (2012); J. Pyzalski, From cyberbullying to electronic aggression: typology of the phenomenon. *Emotional and Behavioural Difficulties*, ***17***, pp. 305-317 (2012).
17. Z. Melosik, Popular culture, pedagogy and the youth. In: J. Pyzalski (Ed.), *Educational and socio-cultural competences of contemporary teachers. Selected issues* (pp. 27-36). Lodz: theQ studio (2015).
18. A. Gromkowska-Melosik, Pop culture icons and idols. Taylor Swift and Barbie as body and identity icons for the youth. In: J. Pyzalski (Ed.), *Educational and socio-cultural competences of contemporary teachers. Selected issues* (pp. 37-44). Lodz: theQ studio (2015).
19. A. Cybal-Michalska & T. Gmerek, Globalisation: educational and socialisation aspect. In: J. Pyzalski (Ed.), *Educational and socio-cultural competences of contemporary teachers. Selected issues* (pp. 9-26). Lodz: theQ studio (2015).
20. J. Morbitzer, Cultural context of the Internet. In. B. Kurowska & K. Lapot-Dzierwa (Eds.), *Kultura – Sztuka – Edukacja* (pp. 181-191). Krakow: Wydawnictwo Naukowe Uniwersytetu Pedagogicznego (2015).

the world of today, one talks about the tyranny of the moment, supermarket of culture or McDonaldized society[21]). Under such conditions, the permanent need to learn becomes a standard, and this applies not just to informal learning, but also to the institutionalized one[22]. The topic of learning is thus in a sense fashionable, and studies on lifelong learning are a sort of a trend in research[23].

For the contemporary educational practice, it is thus desirable to run interdisciplinary theoretical analyses and empirical studies in cognitive neuroscience paradigms into innovative methods of supporting learning with new technologies. When the operations of the European Cooperation in Science and Technology Action related to CyberParks (TUD COST Action TU1306), that I was appointed to as a Management Committee Member by the Minister of Science and Higher Education in Poland, started in April 2014, it was clear to me that it should encompass such analyses and research. However, at that time no-one even actually knew what CyberParks were[24], and the Memorandum of Understanding of this Action only signalled it (without any theoretical references) that CyberParks can in a sense be spaces for learning with the use of new technologies (see Appendix A). It also turned out that no-one around the world had ever dealt with the issue of learning in CyberParks. I therefore decided to study it by applying the above-mentioned assumptions, and this book is the final result of this research. Its elementary objective is thus an interdisciplinary, theoretical and empirical analysis (using the research paradigms of cognitive neuroscience) of the concept of learning in CyberParks. I can therefore state that this book is a form of continuation of my research interests and it appears to be the integral part of my research biography.

My numerous stays at various research centres, including the postdoctoral internship in the Interdisciplinary Research Centre for Education and Development (CeiED) at the Lusofona University of Humanities and Technologies

21. H. Krauze-Sikorska, A child as a person: child's quality of life in the world of (un)perfect parents. In: H. Krauze-Sikorska and M. Klichowski (Eds.), *The educational and social world of a child. Discourses of communication, subjectivity and cyborgization* (p. 310). Poznan: Adam Mickiewicz University Press (2015).
22. A. Cybal-Michalska, Proactivity in a career as a strategy of the intentional construction of an individual future in the world oriented toward a global change. *Procedia Manufacturing, **3***, pp. 3644-3650 (2015).
23. E. Solarczyk-Ambrozik, Career planning – demand for career consultancy – social policy and practice. In: J. Pyzalski (Ed.), *Educational and socio-cultural competences of contemporary teachers. Selected issues* (pp. 167-173). Lodz: theQ studio (2015).
24. S. Thomas, CyberParks will be intelligent spaces embedded with sensors and computers. *The Conversation* (2014).

(Portugal), and discussions with researchers from around Europe, allowed me to notice that the idea of learning in CyberParks should be planted on the assumptions of a larger concept called smart learning. What is more, applying a formal dimension, learning in CyberParks should be perceived as an element of the smart education concept, i.e. formal education completed in the smart city. Figure 0.1 presents such a background of the idea of learning in CyberParks.

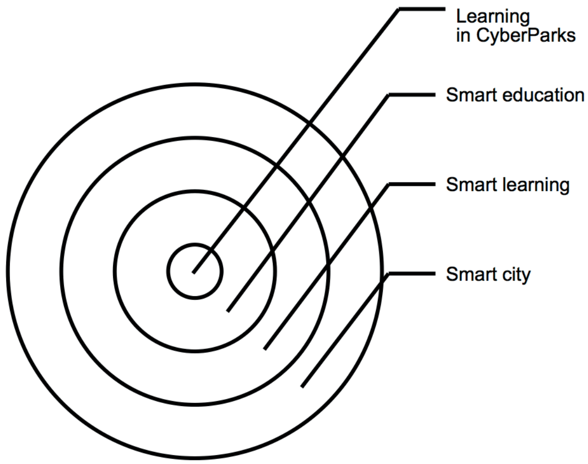


Figure 0.1. Learning in CyberParks as a part of smart learning. Learning in CyberParks is a potential element of smart learning. Using CyberParks in formal learning, learning in CyberParks additionally becomes an element of smart education, i.e. the concept of formal education in the smart city. Source: own work.

Moreover, in the course of further quests, I managed to determine it that from the perspective of learning theories, learning in CyberParks is a part of technology-enhanced outdoor learning (or more precisely: it assumes the form of technology-enhanced outdoor learning). Learning in CyberParks is thus located at the intersection of two large didactic theories: technology-enhanced learning and outdoor learning that have begun to be linked recently for the first time in history. Figure 0.2 presents such a location of the concept of learning in CyberParks among the theories of learning.

Thus, the first, theoretical part of this book includes a discussion on those concepts that are constitutive for the idea of learning in CyberParks. And so, Chapter 1 is dedicated to technology-enhanced learning, including smart learning, Chapter 2 to outdoor learning and finally Chapter 3 refers to technology-enhanced outdoor learning, particularly underlining smart education (and its background, i.e. smart city). It is also in Chapter 3 that the history of CyberParks is described, as well as what their common understanding is.

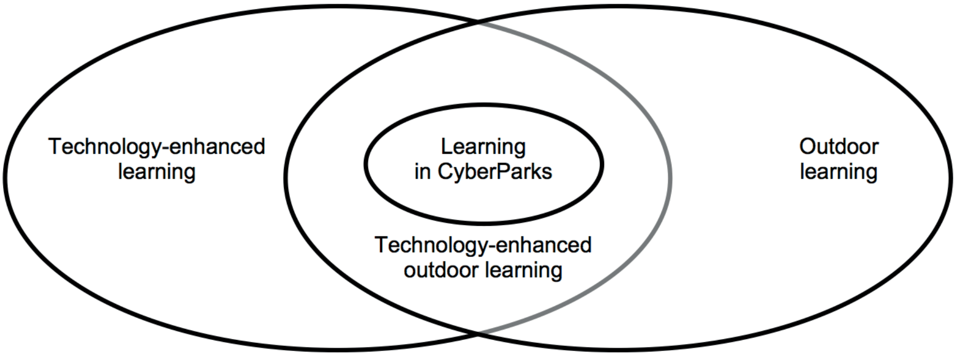
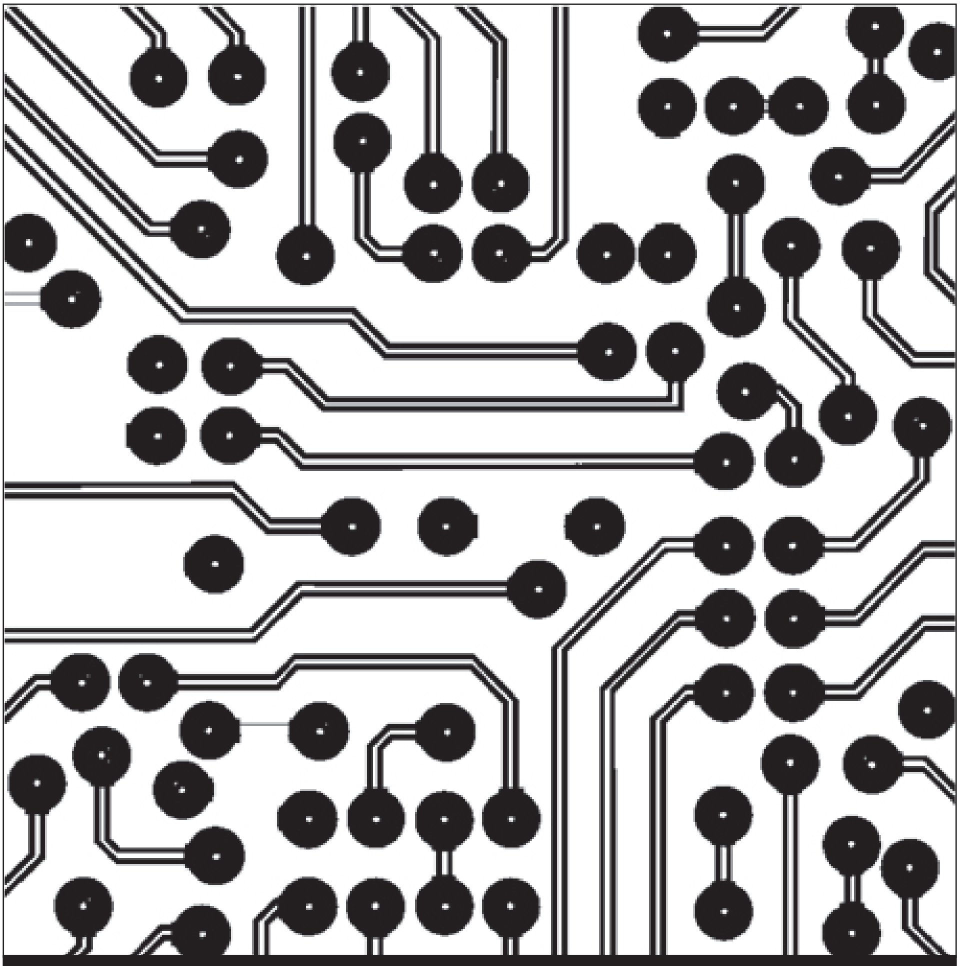


Figure 0.2. Learning in CyberParks as a part of technology-enhanced outdoor learning. Learning in CyberParks is completed in the form of technology-enhanced outdoor learning, thus it is located at the intersection of two large theories of learning: technology-enhanced learning and outdoor learning. Source: own work.

Still, theoretical analyses of the concept of learning in CyberParks lead one to a surprising discovery: one of the latest concepts of neuroscience (the dual-task cost concept) suggests that not only can learning in CyberParks be ineffective, but it can also be dangerous in a way for students. In order to investigate this issue, two experiments in the cognitive neuroscience paradigm were carried out whose assumptions and results were presented in the second part of the book.

The book ends with a discussion directed not only at the interpretation of the results achieved, but also applying them in practice. It suggests some reformulation of the assumptions of CyberParks that will allow them to become not only spaces for safe learning, but also an element of formal education.



PART I

Learning in CyberParks – a theoretical study

CHAPTER 1

Technology-enhanced learning

Introduction

Currently, the influence of new technologies, in particular information and communications technology (ICT), on the functioning of humans is so big that these technologies are more and more frequently introduced into human development models as one of their significant determinants. This process can be excellently exemplified with the idea of expanding the now iconic Bronfenbrenner's model of the Ecological Systems Theory with a new development subsystem: Techno-Subsystem[25]. Bronfenbrenner "has distinguished four ecosystems, namely, microsystem, mesosystem, exosystem and macrosystem, while from an ecological perspective, development is defined as the person's evolving conception of the ecological environment, and his/her relation to it, as well as the person's growing capacity to discover, sustain, or alter its properties"[26].

According to Johnson and Puplampu[27], the authors of the idea of expanding this model with a new technological context, the Techno-Subsystem becomes a new dimension of the microsystem, and actually – which can be seen in Figure 1.1 – it mediates (two-directionally) between the individual and the microsystem. Ignatova, Dagiene and Kubilinskiene[28] notice that balancing this interaction, understood not only as a balanced adaptation to the techno-

25. G.M. Johnson & K.P. Puplampu, Internet use during childhood and the ecological techno-subsystem. *Canadian Journal of Learning and Technology,* ***34*** (2008).
26. N. Ignatova, V. Dagiene & S. Kubilinskiene, ICT-based learning personalization affordance in the context of implementation of constructionist learning activities. *Informatics in Education,* ***14***, p. 54 (2015).
27. G.M. Johnson & K.P. Puplampu, op. cit.
28. N. Ignatova, V. Dagiene & S. Kubilinskiene, op. cit., p. 54.

logical environment, but also a conscious and constructive engagement in the process of its transformation, is incredibly important for building a positive approach to learning in the contemporary world.

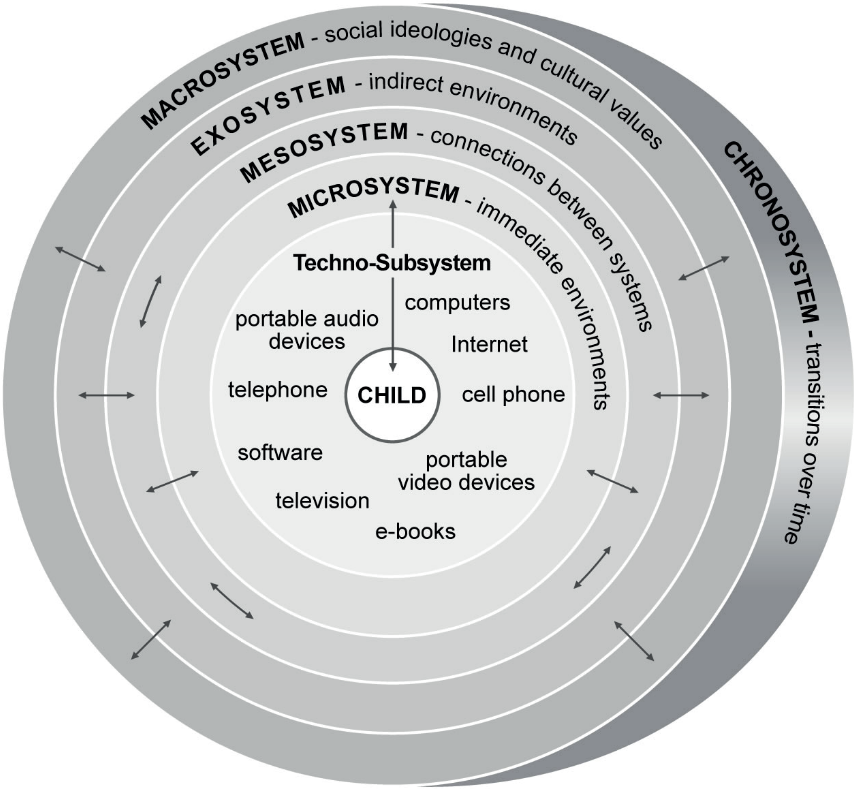


Figure 1.1. The Techno-Subsystem: a new dimension of the Bronfenbrenner's model of the ecological systems theory. Source: G.M. Johnson & K.P. Puplampu, Internet use during childhood and the ecological techno-subsystem. *Canadian Journal of Learning and Technology, **34*** (2008). Under the terms of the Creative Commons Attribution License.

It is quite commonly agreed that at present learning cannot be separated from technology any more. According to Trepule, Teresevičiene and Rutkiene[29], learning and technology have not only ceased to be rivals, but have actually become compatible, or even created a synergy. Thus, as the authors notice, currently the "learning process may not be thought or planned separated

29. E. Trepule, M. Teresevičiene & A. Rutkiene, Didactic approach of introducing technology enhanced learning (TEL) curriculum in higher education. *Procedia – Social and Behavioral Sciences, **191***, pp. 848-849 (2015).

from technology"[30]. Misut and Pribilova[31] even claim that the introduction of technology into the learning process has to become a common education standard, an obligatory and natural thing. This natural character does not mean, however, that changing the learning process in this way, i.e. implementing technology-enhanced learning (TEL) in education, is not a sort of breakthrough for the reality of learning[32]. According to Yusuf and Al-Banawi[33], "TEL can potentially bring about a revolution in learning, making high-quality, cost-effective education available to a greater number of people".

What is TEL and how should we understand it? How has the history of the creation of TEL developed? What are the most up-to-date approaches to TEL? Is the viability of TEL supported by latest research results? This chapter is an attempt at answering these questions. In the first paragraph, definitions of TEL will be discussed. In the next one, the history of TEL will be presented, with the latest approaches mentioned. The third paragraph will be aimed at answering the last question, i.e. the perspective of the most recent research. The chapter will end with an attempt at a short description of the most important issues related to TEL, selected in line with the topic covered by this book.

1.1. Technology-enhanced learning concept

To put it simply, TEL – as indicated by Almpanis[34] – means each type of learning "assisted by digital technology". Kehrwald and McCallum[35] underline, however, that above all it is key that TEL must refer to "situations in which technology is used to enhance the learners' experiences". For this reason, it is assumed that TEL means not only the process of learning with the use of

30. Ibidem, p. 848.
31. M. Misut & K. Pribilova, Measuring of quality in the context of e-learning. *Procedia – – Social and Behavioral Sciences, **177***, p. 317 (2015).
32. S. Gaspar Martins & V. Duarte Teodoro, ActivMathComp – computers and active learning as support of a whole learning environment to calculus/mathematical analysis. *International Journal of Innovation in Science and Mathematics Education, **24***, p. 37 (2016).
33. N. Yusuf & N. Al-Banawi, The impact of changing technology: the case of e-learning. *Contemporary Issues in Education Research, **6***, p. 173 (2013).
34. T. Almpanis, Staff development and institutional support for technology enhanced learning in UK universities. *Electronic Journal of e-Learning, **13***, p. 380 (2015).
35. B.A. Kehrwald & F. McCallum, Degrees of change: understanding academics experiences with a shift to flexible technology-enhanced learning in initial teacher education. *Australian Journal of Teacher Education, **40***, p. 43 (2015).

technologies, but the process of learning that is strengthened, improved, enriched and enhanced by technologies[36]. TEL should thus be viewed as a process that supports and enhances "any learning activity through technology"[37].

Arh, Blazic and Dimovski[38] observe that from this perspective TEL is not just a strategy for introducing technologies into learning in order to modernize this process, but it is a certain new approach to the whole process of learning. When trying to characterize TEL, Kehrwald and McCallum[39] thus underline that it is virtually always associated with diverse educational innovations based on new technologies such as:

- "Active approaches to learning which involve both creation and use of rich multimedia digital resources.
- Purposefully designed learning tasks which employ technology to promote cognitive engagement with program content.
- Collaborative learning situations in which communication is mediated by technology.
- The personalisation of learning experiences afforded by the use of flexible learning technologies.
- Improving learners' access to authentic learning and practice contexts with networked technologies [...].
- Connecting learners with knowledgeable teachers, coaches, mentors and peers who can support learning"[40].

By referring themselves to the directives of Universal Design created at the Center for Universal Design at North Carolina State University (especially to Universal Design for Instruction and Universal Design for Learning) and assuming that the design of products and environments should be "usable by all people, to the greatest extent possible, without the need for adaptation or specialized design"[41], Morra and Reynolds[42] specify that TEL should also

36. C.M. Foshee, S.N. Elliott & R.K. Atkinson, Technology-enhanced learning in college mathematics remediation. *British Journal of Educational Technology, **47***, p. 896 (2016).
37. T. Arh, B.J. Blazic & V. Dimovski, The impact of technology-enhanced organisational learning on business performance: an empirical study. *Journal for East European Management Studies, **17***, p. 370 (2012).
38. Ibidem, pp. 370-371.
39. B.A. Kehrwald & F. McCallum, op. cit., p. 43.
40. Ibidem.
41. T. Morra & J. Reynolds, Universal design for learning: application for technology-enhanced learning. *Inquiry, **15***, p. 43 (2010).
42. Ibidem.

be associated with such educational and technological strategies in order to reduce "learning barriers", take "needs of all learners"[43] into account and make it possible for "flexible learning environments"[44] to be built.

By adapting this understanding of TEL, it is easy to notice that this concept has a very interdisciplinary character[45]. Most often, TEL is described as an area linked to education and computer science, as well as psychology (mainly: educational psychology)[46]; however, scientometric analyses carried out by Kalz and Specht[47] showed that TEL is also strongly rooted in disciplines such as: cognitive science, neurosciences (especially: cognitive neuroscience), anthropology, sociology, information sciences, design studies, instructional design and – yet to a lesser extent – many alike.

Due to the interdisciplinary character and considerable definitional complexity, TEL is sometimes described in literature with other terms, such as for example computer-based learning, technology-mediated learning, and even with narrowing terms such as online learning or web-based learning[48]. Dexter and Dornan[49] underline, however, that in this context TEL is the most suitable name. This name shows that the process refers not only to technologies linked to the Internet (as is the case in online learning and web-based learning) or the computer (computer-based learning), and that its elementary feature is the enhancement of learning (i.e. it is something more than technology-mediated learning).

According to most researchers, the introduction of TEL into education brings about many diverse advantages. At this point, Byrne, Donaldson, Man-

43. Ibidem.
44. Ibidem, p. 49.
45. M. Porta, M. Mas-Machuca, C. Martinez-Costa & K. Maillet, A Delphi study on technology enhanced learning (TEL) applied on computer science (CS) skills. *International Journal of Education and Development using Information and Communication Technology, **8***, p. 48 (2012); M. Kalz & M. Specht, Assessing the crossdisciplinarity of technology-enhanced learning with science overlay maps and diversity measures. *British Journal of Educational Technology, **45***, p. 416 (2014).
46. M.C. Pham, M. Derntl & R. Klamma, Development patterns of scientific communities in technology enhanced learning. *Journal of Educational Technology & Society, **15***, p. 323 (2012); M. Porta, M. Mas-Machuca, C. Martinez-Costa & K. Maillet, op. cit., p. 48; M. Kalz & M. Specht, op. cit., p. 416.
47. M. Kalz & M. Specht, op. cit., pp. 417-427.
48. N. Yusuf & N. Al-Banawi, op. cit., p. 175.
49. H. Dexter & T. Dornan, Technology-enhanced learning: appraising the evidence. *Medical Education, **44***, p. 746 (2010).

da-Taylor, Brugha, Matthews, MacDonald, Mwapasa, Petersen and Walsh[50] point to improved concentration, retention, motivation and satisfaction among students, as well as the fact of giving students more control over the time, space and topics for learning, thus making the process of learning more flexible (this issue will be discussed in more detail further in the paragraph). What is more, according to Seitamaa-Hakkarainen, Viilo and Hakkarainen[51], TEL has a social nature – it applies the concept of active learning based on interactions between all the participants of the process of learning. Zitter, de Bruijn and Simons[52] thus underline that TEL promotes, or even stimulates, the creation of strong connections and relations between "one learner and other learners, between learners and tutors; between a learning community and its learning resources". TEL therefore supports collaborative knowledge building[53], so crucial in the 21st century.

The emphasis on these, and many other, benefits resulting from the application of TEL in education contributes to the common political drive at introducing TEL into the school curriculum in most countries (such directives were also formulated in 2008 in the UNESCO report[54])[55]. The implementation of TEL in the reality of an educational institution is, however, a huge challenge for many countries or some parts/regions of given countries (e.g. rural areas), both in the context of technological infrastructure, and in that related to how teachers are prepared[56]. At some institutions, the application of TEL is still actually completely impossible – for many reasons, especially

50. E. Byrne, L. Donaldson, L. Manda-Taylor, R. Brugha, A. Matthews, S. MacDonald, V. Mwapasa, M. Petersen & A. Walsh, The use of technology enhanced learning in health research capacity development: lessons from a cross country research partnership. *Globalization & Health, **12***, p. 3 (2016).
51. P. Seitamaa-Hakkarainen, M. Viilo & K. Hakkarainen, Learning by collaborative designing: technology-enhanced knowledge practices. *International Journal of Technology and Design Education, **20***, p. 111 (2010).
52. I. Zitter, E. de Bruijn & R.-J. Simons, The role of professional objects in technology-enhanced learning environments in higher education. *Interactive Learning Environments, **20***, p. 120 (2012).
53. E. Byrne, L. Donaldson, L. Manda-Taylor, R. Brugha, A. Matthews, S. MacDonald, V. Mwapasa, M. Petersen & A. Walsh, op. cit., p. 3.
54. UNESCO, *ICT competency standards for teachers: Policy framework*. Paris, p. 13 (2008).
55. N. Law, D.S. Niederhauser, R. Christensen & L. Shear, A multilevel system of quality technology-enhanced learning and teaching indicators. *Journal of Educational Technology & Society, **19***, pp. 73-74 (2016).
56. E. Byrne, L. Donaldson, L. Manda-Taylor, R. Brugha, A. Matthews, S. MacDonald, V. Mwapasa, M. Petersen & A. Walsh, op. cit., p. 3.

related to the lack of access to a necessary technological base, which has to be borne in mind.

Obviously, TEL always requires access to some technology, and acquiring any technological solution – stating the obvious again – always requires building new body of knowledge and financial resources, necessary for instance to buy given tools, software etc., as well as to train teachers or modernize the physical space. It has to be firmly underlined, however, that there are no concrete, clearly categorized technological solutions characteristic of TEL; in TEL it is possible to use all new technologies that enhance learning to any extent. Ng'ambi, Brown, Bozalek, Gachago and Wood[57] indicate that these can be tools that allow for work with electronic texts, illustrations or photographs, as well as everything that gives us access to sounds, voices, and animations and videos recorded. Porta, Mas-Machuca, Martinez-Costa and Maillet[58] notice thus that these can simply be technological solutions of any type, from electronic toys, to computer games, applications, tablets and smartphones, to advanced software and very complicated machines. In short, TEL is open to everything that technologically enhances learning.

Even though TEL is based on an interdisciplinary approach and is a very complex process where virtually every kind of technology can be used, researchers try to list the tendencies that can be observed in the area of TEL, attempt at distinguishing some trends in TEL or simply directions of particular development of TEL. An excellent example of research in this area can be that carried out by Hsu, Hung and Ching[59]. They analysed nearly 3,000 abstracts of academic articles published between 2000 and 2010 in six very prestigious journals devoted to topics related to TEL. These were:

– *British Journal of Educational Technology*.
– *Computers & Education*.
– *Journal of Educational Technology and Society*.
– *Educational Technology Research and Development*.
– *Innovations in Education and Teaching International*.

57. D. Ng'ambi, C. Brown, V. Bozalek, D. Gachago & D. Wood, Technology enhanced teaching and learning in South African higher education – a rearview of a 20 year journey. *British Journal of Educational Technology,* ***47***, p. 845 (2016).

58. M. Porta, M. Mas-Machuca, C. Martinez-Costa & K. Maillet, op. cit., p. 48.

59. Y.-C. Hsu, J.-L. Hung & Y.-H. Ching, Trends of educational technology research: more than a decade of international research in six SSCI-indexed refereed journals. *Educational Technology Research and Development,* ***61***, pp. 685-705 (2013).

– *Journal of Computer Assisted Learning*[60].

The analyses led the researchers to distinguish 19 trends in the research on TEL:

– Studies on issues of macro view of technology integration.
– Studies on macro view of online learning.
– Studies on e-learning in higher education.
– Studies on educational games.
– Studies on technology-assisted learning.
– Studies on finding how learning styles influence learning.
– Studies on technology adoption.
– Studies on attitudes toward technology.
– Studies on learning community.
– Studies on instructional design.
– Studies on learning objects.
– Studies of assessment in technology-based environments.
– Studies related to multimedia.
– Studies on educational software and simulation.
– Studies on computer-assisted language learning (CALL).
– Studies on developing automated instructional systems.
– Studies on learning interactions and online collaborative learning.
– Studies in online discussions.
– Studies on problem-solving[61].

Figure 1.2 shows the relations between the selected trends in research on TEL.

Up to this point, the considerations show that TEL refers to the whole spectrum of scientific domains, technological solutions, and areas and aspects of learning. Nevertheless, TEL is unambiguously located among theories of learning[62]. In most general terms, TEL is set on the multi-stage learning concept (MSL), based on Aristotle's assumption, as shown by Schmoelz, Swertz, Forstner and Barberi[63], that learning has to crisscross three areas:

– Sensuality and percipience.
– Wit and thinking.
– Ambition and desire.

60. Ibidem, p. 688.
61. Ibidem, pp. 692-694.
62. K. Kirkpatrick & R.J. MacKinnon, Technology-enhanced learning in anaesthesia and educational theory. *Continuing Education in Anaesthesia, Critical Care & Pain, **12***, p. 264 (2012).
63. A. Schmoelz, C. Swertz, A. Forstner & A. Barberi, Does artificial tutoring foster inquiry based learning? *Science Education International, **25***, p. 126 (2014).

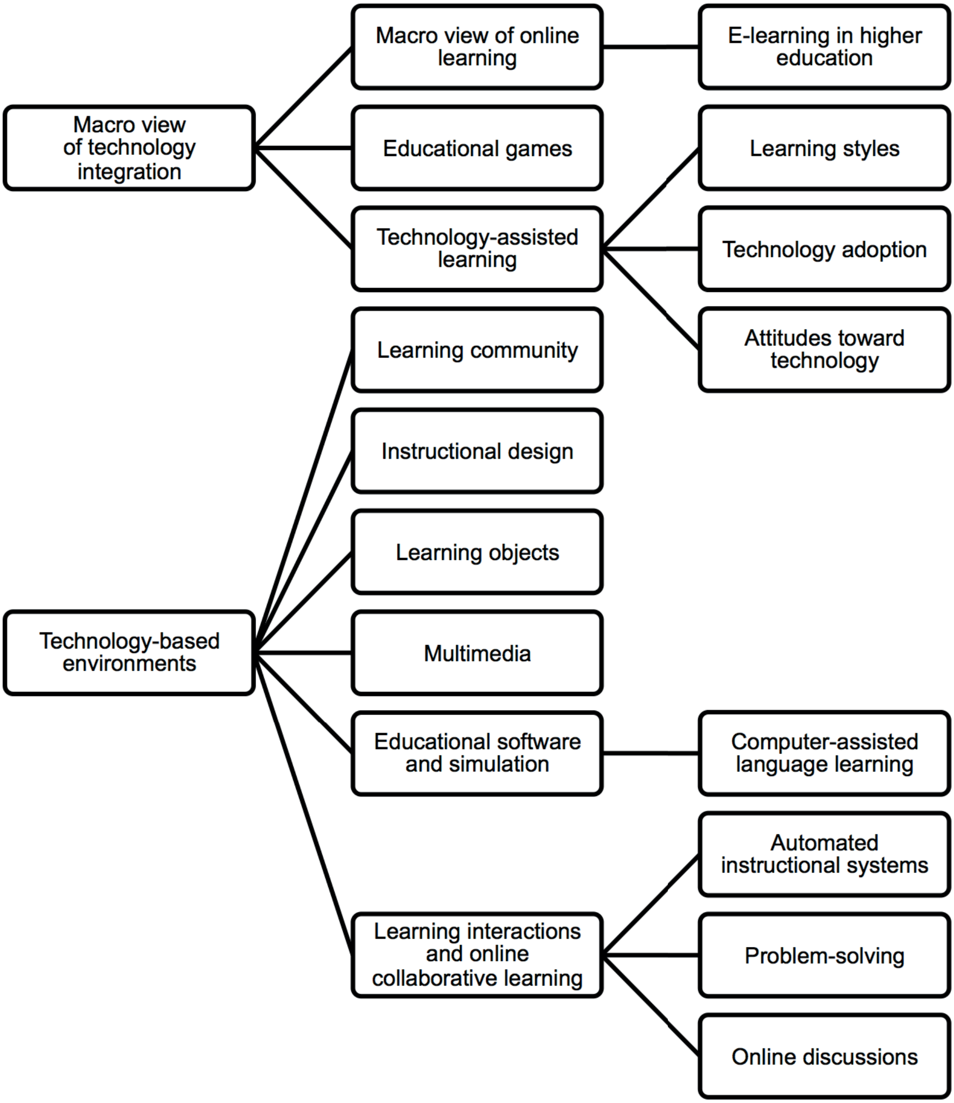


Figure 1.2. Trends in research on technology-enhanced learning and relations between them. Source: own work based on: Y.-C. Hsu, J.-L. Hung & Y.-H. Ching, Trends of educational technology research: more than a decade of international research in six SSCI-indexed refereed journals. *Educational Technology Research and Development*, ***61***, p. 693 (2013).

MSL is sometimes called multi-learning, cognitive apprenticeship or cognitive – associative – autonomous[64]. And it is the last name that shows its actual

64. Ibidem.

meaning. MSL assumes that in order for this Aristotelian assumption to be fulfilled, the learner has to go through three stages of learning[65]. According to Schmoelz, Swertz, Forstner and Barberi[66], these are:

- Cognitive stage: "the learner is trying to figure out what exactly needs to be done and is developing a declarative understanding. That means, the learner is confronted with the topic"[67].
- Associative stage: "the learner needs to associate in relation to his understandings in this field within exercises and assignments"[68].
- Autonomous stage: "the learner is able to solve problems on an expert level, provided that the learner went through the first two stages"[69].

Clearly, referring ourselves to the classification of theories of learning created by Merriam, Cafarella and Baumgartner[70], TEL is based on theories of learning in the group of modern approaches. As analyses by Akyol and Garrison[71] show, these approaches are a kind of consensus between the theories of learning classified as western theories, focused on individuality, freedom and independence (e.g. self-directed learning), and those considered to be eastern theories – promoting collectivism, belonging, harmony and family (e.g. the Confucian way of thinking). Without doubt, in the group of modern approaches it is constructivism[72] that is the most important theory, and the basis for TEL. To put it simply, constructivism is a theory of learning focused on active inquiry and the central role of experience, and at the same time and to the same extent – which is where the consensus can be noticed – collaboration[73].

Without going into details of constructivism, it has to be added that researchers claim that this classic theory of learning (similarly to other classic

65. Ibidem, p. 127.
66. Ibidem.
67. Ibidem.
68. Ibidem.
69. Ibidem.
70. S.B. Merriam, R.S. Caffarella & L.M. Baumgartner, *Learning in adulthood: A comprehensive guide*. San Francisco: John Wiley & Sons (2012).
71. Z. Akyol & D.R. Garrison, Community of inquiry in adult online learning: collaborative-constructivist approaches. In: T.T. Kidd & J. Keengwe (Eds.), *Adult learning in the digital age: perspectives on online technologies and outcomes* (p. 53). Hershey – New York: Information Science Reference (2009).
72. C.S. Chai, L.-H. Wong & R.B. King, Surveying and modeling students' motivation and learning strategies for mobile-assisted seamless Chinese language learning. *Journal of Educational Technology & Society, **19***, p. 172 (2016).
73. Z. Akyol & D.R. Garrison, op. cit., p. 53.

theories of learning such as behaviourism or cognitivism, to name just a few) evolves and develops due to the fast technological development in the recent years. Two of the latest developments of constructivism are particularly important in the context of TEL, namely connectivism and generativism[74].

Connectivism is a theory of learning defined by Siemens as a constructivist theory that matches the standards of the digital age[75]. Buckley and William[76] notice that the researcher coined this phrase "to describe how learning can reside outside the individual and how individuals can contribute to a social network of understanding and knowledge. Connectivism applies to that nebulous entity, the Internet and, one supposes, to the growing use of mobile devices to access, and contribute to, a shared, socially situated body of knowledge". As Steffens[77] shows, connectivism assumes that learning goes through three phases:

- Preparatory phase: searching and taking a decision on the object of learning.
- Actual learning phase: gaining knowledge about the selected object.
- Evaluation and assessment: it can be an element of the second phase and refers to reviewing the acquired knowledge and the ability to apply it.

What is more, connectivism assumes that learning is a process of creating external and internal networks. The external network is comprised of interrelated sources of information of any kind, such as databases, websites, books, journals, libraries, organizations and – obviously – people (of course with a special stress on digital sources or those intermediated by some technology). On the other hand, an internal network is a neural network, or in other words interrelated neural representations of the acquired knowledge[78].

It is also worth underlining that there are eight rules of learning according to connectivism. These are:

- "Learning and knowledge rest in diversity of opinions.
- Learning is a process of connecting specialized nodes or information sources.

74. K. Steffens, Competences, learning theories and MOOCs: recent developments in lifelong learning. *European Journal of Education, **50***, pp. 46-48 (2015).
75. Ibidem, p. 46.
76. C.N. Buckley & A.M. William, Web 2.0 Technology for problem-based and collaborative learning: A Case Study. In: T.T. Kidd & J. Keengwe (Eds.), *Adult learning in the digital age: perspectives on online technologies and outcomes* (p. 119). Hershey – New York: Information Science Reference (2009).
77. K. Steffens, op. cit., p. 46.
78. Ibidem, pp. 46-47.

– Learning may reside in non-human appliances.
– Capacity to know more is more critical than what is currently known.
– Nurturing and maintaining connections is needed to facilitate continual learning.
– Ability to see connections between fields, ideas, and concepts is a core skill.
– Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities.
– Decision-making is itself a learning process. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision"[79].

It can thus be stated that to a large extent connectivism is a theory of learning based on the cooperation with the latest technology, focused on constructing and reconstructing individualized representations of knowledge.

The situation is a bit different when it comes to generativism. As shown by Steffens[80], this theory created by Carneiro assumes that the digital age encourages basing the individual process of constructing knowledge not only on cooperation but above all on socially created knowledge resources. Learning is thus to consist in generating new knowledge from the previously acquired, available e.g. in the form of information included in various types of open educational resources (OER). New knowledge is supposed to be a sort of new meaning generated from the already existing (created before) knowledge. Learning consistent with generativism is thus a meaning-making process, consisting in generating knowledge from the existing information (e.g. stored in electronic resources) and transforming it into a new meaning. This process is presented in Figure 1.3.

Figure 1.3. The course of the process of learning in the generativism theory. Source: own work based on: K. Steffens, Competences, learning theories and MOOCs: recent developments in lifelong learning. *European Journal of Education,* **50**, p. 48 (2015).

79. Ibidem, p. 46.
80. Ibidem, p. 47.

Table 1.1 shows that generative learning is considerably different from the traditional adaptive learning known from most schools. It is focused on generating new, own, individual ways of understanding information produced by the society (especially those made public by social media, but also of any other type)[81].

Table 1.1. A comparative overview of generative learning and traditional adaptive learning. Source: own work based on: K. Steffens, Competences, learning theories and MOOCs: recent developments in lifelong learning. *European Journal of Education*, ***50***, p. 47 (2015).

Generative learning	Adaptive learning
Expanding capabilities	Adjusting to change
Enhancing creativity	Coping with threats
Looking in new ways	Reacting to symptoms
Addressing underlying causes	Capturing trends and incorporating early signs
Thinking differently	Eliciting flexibility
Anticipating the future	Projecting trends
Rewarding knowledge reconstruction	Seeking conventional knowledge

It can thus be acknowledged that generativism is a theory of learning that assumes learning consists in assigning new individual meanings to the knowledge that was previously built and generated on the basis of the existing information (especially that gained through social media).

TEL is thus a theory of learning with the use of (any type of) technology that is applied in order to enrich the cooperation and enable access to social information resources, and at the same time stimulate student's own, individual and creative activity that makes it possible to assign individualized meanings to the elements of reality that they get to know. As Chai, Wong and King[82] notice, such an interpretation of TEL shows that it is a theory of learning of the student-centric oriented type. Student-centred learning is radically different from traditional learning known from a typical school and called teacher-centred approach, where it is the teacher who creates the process of learning and has a monopoly on knowledge – they play the role of a filter, and sometimes even a distributor, of information[83]. How is student-centred learning organ-

81. Ibidem.
82. C.S. Chai, L.-H. Wong & R.B. King, op. cit., p. 172.
83. N. Yusuf & N. Al-Banawi, op. cit., pp. 174-175.

ised? Looi, Seow, Zhang, So, Chen and Wong[84] notice that in such an approach "teachers act as a facilitator and learning partner rather than a sole expert of knowledge". They also add, which becomes an incredibly important trail for this book, that "the mobility and connectivity of technological tools enable students to become an active participant, not a passive receiver in learning activities. For instance, instead of sitting in front of a desktop computer and watching a video simulation, students with mobile devices can go out to the field, directly and physically explore our world, and share their experiences with others"[85]. Applying this terminology used to describe the pedagogy-driven model created by Rahimi, van den Berg and Veen[86], it can be stated that in the student-centric oriented approach the student adopts three new roles (unknown in the teacher-centric oriented approach):

- Content producer role: the student can use technology to assess, search, modify and create content.
- Socialiser role: the student can use technology to search for help from others and cooperate with them.
- Decision maker role: the student can use technology to search and consciously plan learning, including the choice of ways of learning.

Figure 1.4 presents the differences between the teacher-centric oriented approach and student-centric oriented approach.

Based on the understanding of TEL presented, it also appears that it is a theory of learning that matches the outcomes-based education trend defined by Spady, i.e. – to simplify it to the maximum – education focused "on student knowledge production and action and the value creation of learning provisions", as well as based on what each student does and can do at the moment[87]. As Tam[88] notices, such an approach contradicts the traditional, linear

84. C.-K. Looi, P. Seow, B.H. Zhang, H.-J. So, W. Chen & L.-H. Wong, Leveraging mobile technology for sustainable seamless learning: a research agenda. *British Journal of Educational Technology, **41***, p. 156 (2010).
85. Ibidem.
86. E. Rahimi, J. van den Berg & W. Veen, Facilitating student-driven constructing of learning environments using Web 2.0 personal learning environments. *Computers & Education, **81***, p. 236 (2015).
87. E. Dobozy, Learning design research: advancing pedagogies in the digital age. *Educational Media International, **50***, p. 64 (2013).
88. M. Tam, The outcomes-based approach: concepts and practice in curriculum and educational technology design. In: A.D. Olofsson & J.O. Lindberg (Eds.), *Informed design of educational technologies in higher education: enhanced learning and teaching* (pp. 26-28). Hershey: Information Science Reference (2012).

model of education where the state of the student is not taken into account, but where a previously drafted default plan is followed and the focus is on mastering preselected content.

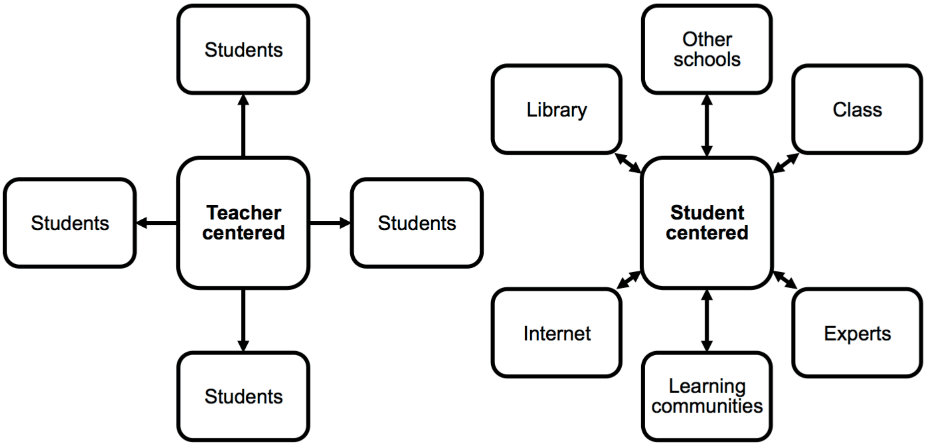


Figure 1.4. The process of learning in the teacher-centric oriented approach and student-centric oriented approach. Source: own work based on: N. Yusuf & N. Al-Banawi, The impact of changing technology: the case of e-learning. *Contemporary Issues in Education Research,* ***6***, p. 175 (2013).

Figure 1.5 illustrates the difference between traditional, linear education and outcomes-based education.

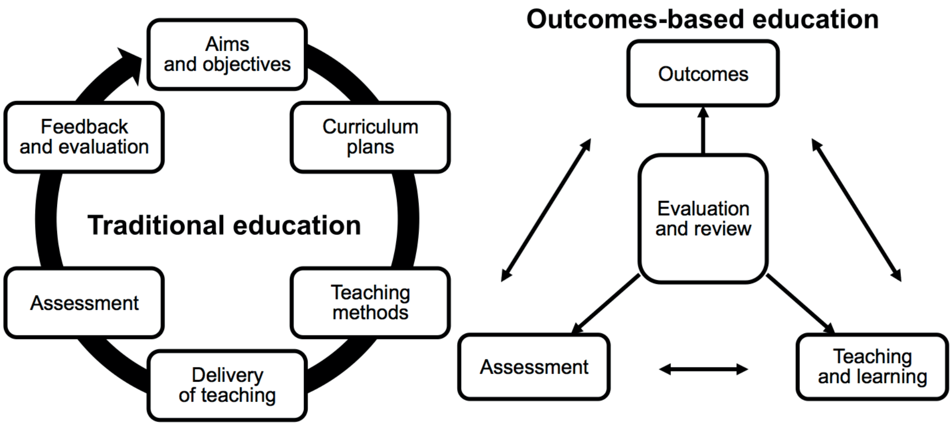


Figure 1.5. The process of learning in traditional education and outcomes-based education. Source: own work based on: M. Tam, The outcomes-based approach: concepts and practice in curriculum and educational technology design. In: A.D. Olofsson & J.O. Lindberg (Eds.), *Informed design of educational technologies in higher education: enhanced learning and teaching* (pp. 26-27). Hershey: Information Science Reference (2012).

It is worth adding that a transformational variant of outcomes-based education is particularly characteristic of TEL. As shown by Dobozy[89], in this approach great emphasis is put on stimulating students' ability to apply the acquired capabilities, skills and knowledge in practice, as well as their ability to solve problems that result from the dynamics of life in the world of today.

Teachers' actions in the educational reality based on the TEL concept are thus – which is also indicated by the analyses by Solvberg and Rismark[90] – a result of interactions among three elements: technologies available, assumptions of learning theories and – obviously – particular issues of educational practice. Each of these elements creates a certain educational space, and the scope of their interferences (determined by a whole spectrum of previously accepted factors linked to the context of implementing new technologies) sets the framework of the actual work of a teacher within TEL. Figure 1.6 shows these interferences schematically.

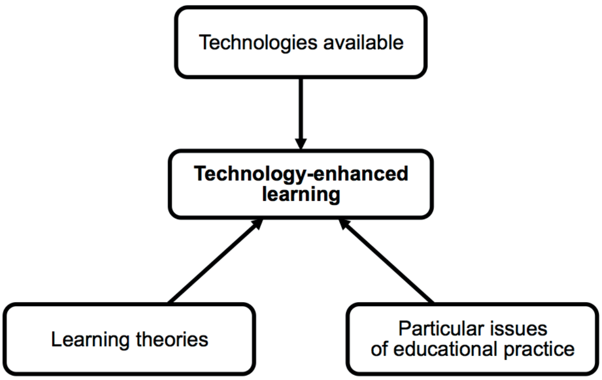


Figure 1.6. The framework of teachers' work in technology-enhanced learning defined by the field of interference of three elements: technologies available, assumptions of learning theories and particular issues of educational practice. Source: own work based on: A.M. Solvberg & M. Rismark, Use of technology in education: didactic challenges. In: R. Krumsvik (Ed.), *Learning in the network society and the digitized school* (pp. 143-146). New York: Nova Science Publishers, Inc (2009).

On the other hand, Law, Niederhauser, Christensen and Shea[91] state that the quality of TEL is determined by four groups of factors:

89. E. Dobozy, op. cit., p. 64.
90. A.M. Solvberg & M. Rismark, Use of technology in education: didactic challenges. In: R. Krumsvik (Ed.), *Learning in the network society and the digitized school* (pp. 143-148). New York: Nova Science Publishers, Inc (2009).
91. N. Law, D.S. Niederhauser, R. Christensen & L. Shear, op. cit., pp. 75-80.

– Factors related to the student: e.g. “personal access to a variety of digital resources to complete school assignments”, ”skills and access to communication tools for enhanced learning opportunities”, ability to choice “in the selection of topics to study and the application of personal learning strategies”[92].
– Factors related to the teacher: e.g. “the number of Internet-connected computers to which teachers have access”, “the number of hours teachers used technology with students”, “time teachers spent in professional development activities”, “teachers’ technological knowledge and skills”, “confidence in their ability to use technology and the value they perceive in using technology to aid in the teaching/learning process”, “the depth of knowledge they have in the content they are teaching”, “their beliefs about how students learn”[93].
– Factors related to the school: e.g. “student-to-computer ratios and access to electricity, connectivity”, “other elements of infrastructure that allow their use”, “technical support to teachers and learners”, “the bandwidth and reliability of Internet access during the school day”, “digital learning resources”[94].
– Factors related to the system: e.g. GDP of the country, “national digital infrastructure such as broadband penetration and home ownership of computational devices”, “extent to which the political system allows/encourages democratic discussion and community participation in policy decisions”[95].

Misut and Pribilova[96] add thus, which may be an interesting summary of the issues underlined above, that TEL should be always viewed as a process determined by at least three groups of factors: technological, economic and pedagogical.

As a result, the following question arises: are there any directives towards TEL that, once completed, could help look after the high quality of learning in this concept? In this context, Trepule, Tereseviciene and Rutkiene[97] list three types of activities with such potential:

92. Ibidem, p. 77.
93. Ibidem, p. 78.
94. Ibidem, p. 79.
95. Ibidem, pp. 79-80.
96. M. Misut & K. Pribilova, op. cit., pp. 313-314.
97. E. Trepule, M. Tereseviciene & A. Rutkiene, op. cit., p. 850.

– Firstly, learners' meta-cognitive skills (e.g. reflection and self-reflection) and self-efficacy through support and guidance should be stimulated.
– Secondly, social presence should be built, through encouraging discussions and creating a community feeling.
– Thirdly, students should be taught how to manage their own time effectively.

On the other hand, Raymond, Iliffe and Pickett[98] propose to use the ACTIONS concept in this context. This acronym refers to seven directives:

– A – Access: actions should be taken in order to use TEL to improve access to the best educational materials that are easy to use and do not require very specialist competences.
– C – Costs: actions should be taken in order to use TEL to decrease the cost of education, especially those burdening students or their caregivers.
– T – Teaching and learning: actions should be taken for teaching and learning to be based on the most reliable knowledge and latest scientific findings.
– I – Interactivity and user-friendliness: actions should be taken for the technological tools to be easy to use for everyone or introduced in a way for everyone to be able to use them freely.
– O – Organisational issues: actions should be taken for the technologies in use and procedures of their application to be adjusted to the specifics of the functioning of the organization where TEL is applied.
– N – Novelty: actions should be taken in order to use TEL to introduce as many novelties into education as possible, both those related to the ways of learning and those referring to the content of learning itself.
– S – Speed: actions should be taken for learning to be as effective as possible.

Esterhuizen[99] also underlines (which is actually a sort of synthesis of the ACTIONS concept) that in TEL it is crucial to strike the right balance in the relation between people and technology. The idea is to use the technologies available to the maximum, but also to use them in a way that allows for the strategy of their application to be based on a decent diagnosis of the abilities

98. M. Raymond, S. Iliffe & J. Pickett, Technology-enhanced learning. *Education for Primary Care,* ***23***, p. 458 (2012).
99. H. Esterhuizen, Seamless support: technology enhanced learning in open distance learning at NWU. *Turkish Online Journal of Educational Technology – TOJET,* ***14***, pp. 130-132 (2015).

and competences of teachers and students, and be coherent with the curriculum. Of course, these abilities and competences are to be developed (also through TEL), and the curriculum modified, yet always to the extent that keeps people–technology interactions in balance.

Even though based on the same assumptions as previously mentioned, Chatti, Jarke and Specht[100] formulate five more directives (also sometimes called the five success factors for TEL), and present a TEL model built on them, called the 3P Learning Model (3P LM). This model is considered to be the most up-to-date and best TEL pattern. These are the directives formulated by the authors:

– Learning must be personal and self-directed: new technologies must be used in a way that makes it possible for learning to be adjusted to the individual needs of each student and for the student to have some control over it[101].
– Learning must be social: new technologies must be used in a way that makes it possible for learning to be submerged in a social context (in the aspect of interactions and social knowledge resources)[102].
– Learning must be open: new technologies must be used in a way that makes it possible for learning to become decentralized, i.e. to be possible at any place, not just in the formal space of a given educational institutions[103].
– Learning must be emergent: new technologies must be used in a way that makes it possible for learning to go away from hierarchy to "wirearchy", understood as "a dynamic two-way flow of power and authority based on information, knowledge, trust and credibility enabled by interconnected people and technology"; command and control should also be abandoned for coordination and channel[104].
– Learning must be driven by knowledge-pull: new technologies must be used in a way that makes it possible to move the stress from knowledge-push in learning (where information is distributed by teachers or given institutions) to a knowledge-pull model (where it is students who navigate the information)[105].

100. M.A. Chatti, M. Jarke & M. Specht, The 3P learning model. *Journal of Educational Technology & Society,* ***13***, pp. 74-75 (2010).
101. Ibidem, p. 74.
102. Ibidem.
103. Ibidem, p. 75.
104. Ibidem.
105. Ibidem.

The name of 3P LM is linked to the three fundaments of the model that result from the directives presented[106]. These are:

- **P**ersonalization: it is understood here in a way where learning must be individualized and learner-controlled[107]. Thanks to technology, students are to have the opportunity to:
  - "Modify course materials using different parameters and a set of pre-defined rules".
  - "Personalize the course materials by themselves".
  - "Set their own learning goals".
  - "Manage their learning" and „both content and process".
  - "Communicate with others in the process of learning"[108].
- **P**articipation: it is understood here not only as learning in the social context and with the use of social knowledge resources, but also (and maybe even above all) as the Learning as a Network (LaaN)[109]. In LaaN, participation refers to "personal horizontal connections", i.e. to anchoring in "the center of our very own personal knowledge network" (PKN). PKN thus goes beyond the framework of a group or local community, institution or resources available, and assumes the use of technology to go beyond any formal barriers for learning[110].
- Knowledge-**P**ull build: this approach consists in providing students with access to "a plethora of tacit/explicit knowledge nodes"[111]. Students are also supposed to have control over these nodes, i.e. they are supposed to take independent decisions about the methods of their selection and connection. Knowledge-Pull build is thus (as opposed to the traditional finite list of possible areas of learning, known from traditional schools) a strategy of using technology to enrich personal knowledge networks of students, through opening to the areas of learning resulting from students' interests[112].

3P LM is thus supposed to highlight that the most modern TEL model is the one that moves in the direction of "a more personalized, social, open, dynamic, emergent and knowledge-pull model for learning, as opposed to the

106. Ibidem, pp. 76-83.
107. Ibidem, p. 76.
108. Ibidem, pp. 76-79.
109. Ibidem, pp. 80-82.
110. Ibidem, p. 80.
111. Ibidem, p. 82.
112. Ibidem, pp. 82-83.

one-size-fits-all, centralized, static, top-down, and knowledge-push models of traditional learning models”[113]. Figure 1.7 illustrates the component parts of 3P LM and the relations between them.

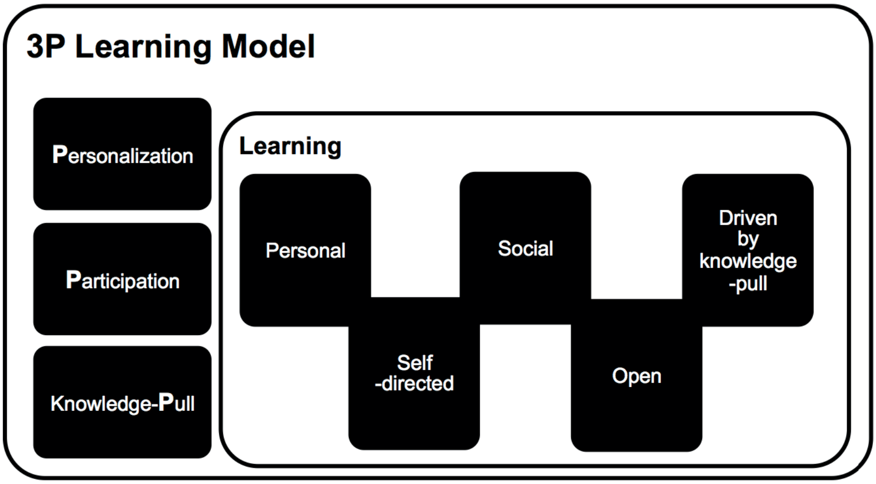


Figure 1.7. The 3P Learning Model as a pattern model for technology-enhanced learning. Source: own work based on: M.A. Chatti, M. Jarke & M. Specht, The 3P learning model. *Journal of Educational Technology& Society, **13***, p. 75 (2010).

The previously asked question about whether there are any directives with respect to TEL the completion of which would make it possible to care for the high quality of learning in this concept is provided with a very interesting answer by Krumsvik and Almas[114], which may be an intriguing summary to this issue. By referring themselves to the famous Fullan’s study, they notice that these directives are exactly the same as those that refer to any other innovative solutions (also those not based on new technologies) introduced in education. As inferred from Fullan’s conclusions, these are:

- Good relationship between teachers.
- Support from the school management.
- A clear timeline.
- Staff development and participation.
- Good communications.

113. Ibidem, p. 84.

114. R. Krumsvik & A.G. Almas, The digital didactic. In: R. Krumsvik (Ed.), *Learning in the network society and the digitized school* (pp. 108-109). New York: Nova Science Publishers, Inc (2009).

– An internal/local consultant to support teachers[115].

Irrespective of what new technology teachers use, if these conditions are fulfilled, the technology will enhance learning – collating the previous considerations with the narration of these authors. TEL will thus be effective.

To summarize this subchapter, it can thus be stated that TEL is not something fully defined – it is an open concept, promoting the use of any type of new technologies to improve any sort of aspects of the process of learning. TEL is also – which in a way leads us to the next subchapter – a result of a considerably long history of including technology in education and it is also a sort of a phraseological compromise of this history[116]. What is more, as noticed by Steffens[117], the history of TEL shows that the most up-to-date theories of learning based on technological tools are in a way the underpinnings of deconstructing the classic idea of the learning society and replacing it with the idea of the learning city, which is an exceptionally important context for the considerations in this book. This thread will become the topic for further considerations, especially those included in Chapter 3, where concepts of smart cities, smart education and – most importantly – CyberParks will be presented.

1.2. The history of technology-enhanced learning

To no surprise, the history of TEL is closely linked to the history of the development of new technologies, especially of various ICT tools – above all, to those aspects of this history that refer to the popularization of innovative technologies and their increased egalitarianism[118]. Table 1.2 shows the most important moments in this history and the technologies that were created in a given period or started to be popularised.

Even though the beginnings of TEL can be already seen in the actions taking part in the first decade of the 20th century, such as the introduction of film into education or – slightly later, i.e. in the 1920s – the construction

115. Ibidem.
116. M. Jenkins, T. Browne, R. Walker & R. Hewitt, The development of technology enhanced learning: findings from a 2008 survey of UK higher education institutions. *Interactive Learning Environments, **19***, p. 448 (2011).
117. K. Steffens, op. cit., p. 49.
118. M.J. Cox, Formal to informal learning with IT: research challenges and issues for e-learning. *Journal of Computer Assisted Learning, **29***, pp. 86-89 (2013).

Table 1.2. A brief history of the development of new technologies crucial for education. Source: own work based on: M.J. Cox, Formal to informal learning with IT: research challenges and issues for e-learning. *Journal of Computer Assisted Learning,* ***29***, p. 87 (2013).

Dates/Era	Technologies
1968	ARPANET
1970-1977	Real-time interactive computers Remote access to computers from different locations
1977-1980	Small desktop computers, e.g. Horizon, Apple II, RML 380z, IBM series, Acorn atom computer, Acorn BBC – Model A (8 k of memory), Acorn BBC model B (32 k of memory) Disk-based storage of computer programs (instead of tape-based storage) Prestel/Teletext
1980-1984	First Apple-Macintosh Fibre optics Concept keyboard/graphics tablets Quinkey keyboard Robot turtle Tracker ball Touch screens Speech input and output
1985-1987	Microsoft Windows More powerful and cheaper personal microcomputers, e.g. IBM PC and Mac II World Wide Web (WWW)
1987-1990	CD-ROM Interactive video Plug-in memory cards
1990-1995	Lap-top computers Wireless computer networks Air-mouse Video-conferencing
1996-1999	Electronic interactive whiteboard Personal digital assistants (PDAs)
2000-2004	Expansion of mobile hand-held technologies, e.g. mobile phones and MP3 players Molecular computing technology Quantum computers
2005-2007	Widespread access to wireless networks and interactive whiteboards Web 2.0 technology, e.g. Wikipedia, Second Life
2007-	Smartphones, e.g. iPhone Tablets, e.g. iPad Ebooks Facebook Blogs Twitter One World TV ...

of Sidney Pressey's mechanical teaching machines, it was in the 1960s which begin the above table that the actual history of TEL started[119]. It was when first classroom systems based on linked computer terminals were created at schools and first serious experiments started to be conducted on the sense of introducing technological tools into the process of education[120].

However, as shown by Kaware and Sain[121], the real expansion of TEL took place in the 1970s and 1980s. At that time, computer costs started to decrease, and there was a peculiar explosion of strategies aimed at their miniaturization. It was when Turoff and Hiltz created the concept of computer-based learning; Luskin, using the television station KOCE-TV at the Coastline Community College, coined the famous idea of "college without walls"; and the following solutions were created: computer-based training (CBT), computer-based learning (CBL), networking in education, distance learning courses using computer networking for information, early e-learning systems, computer supported collaborative learning (CSCL). Moreover, in this period many countries started political actions in favour of the promotion (and sometimes even compulsory nature) of introducing new technologies into schools.

At the beginning of the 1990s, the World Wide Web started to be used in education, which was the most important turning point in the history of TEL[122]. Virtual courses started to be created, and teachers started to give classes via websites. As early as in 1993, Graziadei described how to electronic mail in teaching, and in 1994 the first online high school was established, as well as the first online curriculum of CAL Campus (online-based school)[123] was created.

On the other hand, the 21st century is a time of fast, small, mobile, personalised, social and ubiquitous, or even smart, technological tools. That is also what 21st-century education is to be like as viewed by TEL: faster, mobile,

119. S.S. Kaware & S.K. Sain, ICT application in education: an overview. *International Journal of Multidisciplinary Approach and Studies, **2***, p. 26 (2015).

120. M.J. Cox, op. cit., p. 86.

121. S.S. Kaware & S.K. Sain, op. cit., pp. 26-27.

122. M. Klichowski & C. Patricio, Does the human brain really like ICT tools and being outdoors? A brief overview of the cognitive neuroscience perspective of the CyberParks concept. In: A. Zammit & T. Kenna (Eds.), *Enhancing Places through Technology. Proceedings from the ICiTy conference* (pp. 223-225). Lisbon: Edicoes Universitarias Lusofonas (2017).

123. S.S. Kaware & S.K. Sain, op. cit., p. 27.

adjusted to individual needs of students, based on the cooperation of all subjects of the process of learning, and also "total", i.e. covering all places of existence[124]. Today, TEL is thus supposed to be understood as smart education[125], which is an important bridgehead for the most crucial consideration in this book. In order to understand really well what smart education is supposed to be, one should – as noticed by Jang[126] – follow through the latest (elementary for smart education) stages of the history of TEL, i.e. have a look at (globally and without going into detail irrelevant for this book) the concepts: e-learning, m-learning, u-learning and smart learning (see Figure 1.8). This will also help to logically internalize the dynamics of the growing faith (and, as will be shown later, a faith not fully grounded in academic discourse) in the sense of increasingly supporting the process of learning with new technologies[127]. For the clarity of argument, each of these concepts will be described in separate paragraphs.

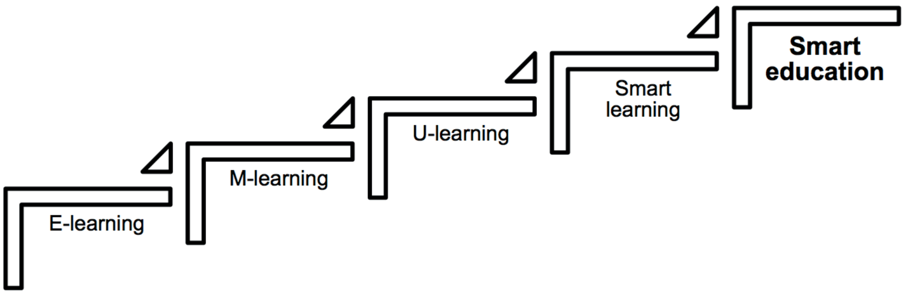


Figure 1.8. The latest stage of the history of technology-enhanced learning as a basis for smart education. Source: own work based on: S. Jang, Study on service models of digital textbooks in cloud computing environment for SMART education. *International Journal of u- and e- Service, Science and Technology*, ***7***, p. 75 (2014).

124. M.J. Cox, op. cit., pp. 89-100.
125. M. Klichowski, P. Bonanno, S. Jaskulska, C. Smaniotto Costa, M. de Lange & F. Klauser, CyberParks as a New Context for Smart Education: Theoretical Background, Assumptions, and Pre-service Teachers' Rating. *American Journal of Educational Research*, ***3***, pp. 2-3 (2015).
126. S. Jang, Study on service models of digital textbooks in cloud computing environment for SMART education. *International Journal of u- and e- Service, Science and Technology*, ***7***, pp. 74-75 (2014).
127. B. Gan, T. Menkhoff & R. Smith, Enhancing students' learning process through interactive digital media: new opportunities for collaborative learning. *Computers in Human Behavior*, ***51***, p. 652 (2015).

1.2.1. E-learning

E-learning, or electronic learning[128], is defined in many different ways, yet it always refers to a variety of actions linked to the use of electronic communication in order to unite some participants of the process of learning or bring them together with various educational resources[129]. E-learning is thus based on a variety of computer network technologies[130]. E-learning is therefore a concept of learning that goes beyond the normal CBL, because its essence is not the use of a computer itself in the process of learning, but interactive learning through a computer that forms a part of a computer network[131].

Kirkpatrick and MacKinnon[132] notice that most contemporary activities in the area of e-learning refer to learning with the use of the Internet. Numerous strategies of various kind have been created as far as the use of the Net to support learning is concerned, for example the popular Massive Open Online Courses (MOOCs)[133], or Small Private Online Courses (SPOCs)[134] that are gaining popularity, or – slightly dying out – learning in 3D Virtual Worlds[135]. Many researchers underline, however, that – from the point of view of the ac-

128. H. Salehi, M. Shojaee & S. Sattar, Using e-learning and ICT courses in educational environment: a review. *English Language Teaching, **8***, p. 63 (2015).
129. M. Misut & K. Pribilova, op. cit., p. 313.
130. I. Ha & C. Kim, The research trends and the effectiveness of smart learning. *International Journal of Distributed Sensor Networks, **2014***, pp 3 (2014).
131. A. Tlili, F. Essalmi, M. Jemni, Kinshuk & N.-S. Chen, Role of personality in computer based learning. *Computers in Human Behavior, **64***, p. 806 (2016).
132. K. Kirkpatrick & R.J. MacKinnon, op. cit., p. 263.
133. J. Bimrose, A. Brown, T. Holocher-Ertl, B. Kieslinger, C. Kunzmann, M. Prilla, A.P. Schmidt & C. Wolf, The role of facilitation in technology-enhanced learning for public employment services. *International Journal of Advanced Corporate Learning, **7***, p. 56 (2014); E.S. Acosta, J.J. Escribano Otero & G.C. Toletti, Peer review experiences for MOOC. Development and testing of a peer review system for a Massive Online Course. *The New Educational Review, **37***, pp. 66-79 (2014); J.I. Aguaded-Gomez, The MOOC revolution: a new form of education from the technological paradigm? *Comunicar, **41***, pp. 7-8 (2013); M. Andronie & M. Andronie, Information and communication technologies (ICT) used for education and training. *Contemporary Readings in Law & Social Justice, **6***, pp. 378-386 (2014); G. Kranz, MOOCs: the next evolution in e-learning? *Workforce, **93***, p. 10 (2014).
134. P.J. Munoz-Merino, J.A. Ruiperez-Valiente, C. Alario-Hoyos, M. Perez-Sanagustin & C.D. Kloos, Precise effectiveness strategy for analyzing the effectiveness of students with educational resources and activities in MOOCs. *Computers in Human Behavior, **47***, p. 108 (2015).
135. M. Aristeidou & N. Spyropoulou, Building technology and science experiences in 3D virtual world. *Procedia Computer Science, **65***, pp. 259-268 (2015); T. Kotsilieris & N. Di-

tual state of development of education – the most accurate way of using the concept of e-learning at school is to create the so-called flipped classroom. The flipped classroom – or more precisely, as underlined by Hao and Lee[136], technology-integrated flipped classrooms – is a blended learning approach[137], i.e. a concept of learning located between the conventional concept of face-to-face learning, and the concept of fully online learning that is entirely based on interactions online (see Figure 1.9)[138].

Figure 1.9. The position of blended learning on the continuum of approaches to using the Internet in the process of learning. Source: own work based on: G. Finger, P.-C. Sun & R. Jamieson-Proctor, Emerging frontiers of learning online: digital ecosystems, blended learning and implications for adult learning. In: T.T. Kidd & J. Keengwe (Eds.), *Adult learning in the digital age: perspectives on online technologies and outcomes* (p. 5). Hershey – New York: Information Science Reference (2009).

The flipped classroom concept assumes that the Net is used out of the classroom. Students familiarize themselves with the material on the Internet before the class, so that in class the teacher has as much time as possible to work on a given topic with the students, e.g. by running a discussion or creating a situation that makes it possible to solve practical problems. The teacher also uses the Net exclusively before the class, designing given materials for the students[139].

In this context, Munoz-Merino, Ruiperez-Valiente, Alario-Hoyos, Perez-Sanagustin and Kloos[140] give the following example of activities that match the

mopoulou, The evolution of e-learning in the context of 3D Virtual Worlds. *The Electronic Journal of e-Learning, **11***, pp. 147-167 (2013).

136. Y. Hao & K.S. Lee, Teaching in flipped classrooms: exploring pre-service teachers' concerns. *Computers in Human Behavior, **57***, p. 250 (2016).
137. T. Wanner & E. Palmer, Personalising learning: exploring student and teacher perceptions about flexible learning and assessment in a flipped university course. *Computers & Education, **88***, p. 356 (2015).
138. G. Finger, P.-C. Sun & R. Jamieson-Proctor, Emerging frontiers of learning online: digital ecosystems, blended learning and implications for adult learning. In: T.T. Kidd & J. Keengwe (Eds.), *Adult learning in the digital age: perspectives on online technologies and outcomes* (p. 5). Hershey – New York: Information Science Reference (2009).
139. Y. Hao & K.S. Lee, Teaching in flipped classrooms... op. cit., pp. 250-251.
140. P.J. Munoz-Merino, J.A. Ruiperez-Valiente, C. Alario-Hoyos, M. Perez-Sanagustin & C.D. Kloos, op. cit., p. 108.

flipped classroom concept: "students watch videos with the theoretical concepts from home and practice these concepts with automatic correction exercises, and later attend to the classroom to solve problems with teachers". At this stage it needs to be firmly underlined, as shown by Wanner and Palmer[141], among others, that the central part of the flipped classroom concept is "the face-to-face interaction where active learning takes place" – using the Internet is supposed to reinforce the traditional forms of learning with a teacher, and not replace them. As shown by Yousef, Chatti and Schroeder[142], the flipped classroom concept is thus used to "supplement traditional classroom approach" (see Figure 1.10A). Cox[143] notices, however, that in the future this relation may be reverse. Traditional face-to-face learning will be therefore used exclusively to supplement e-learning (see Figure 1.10B).

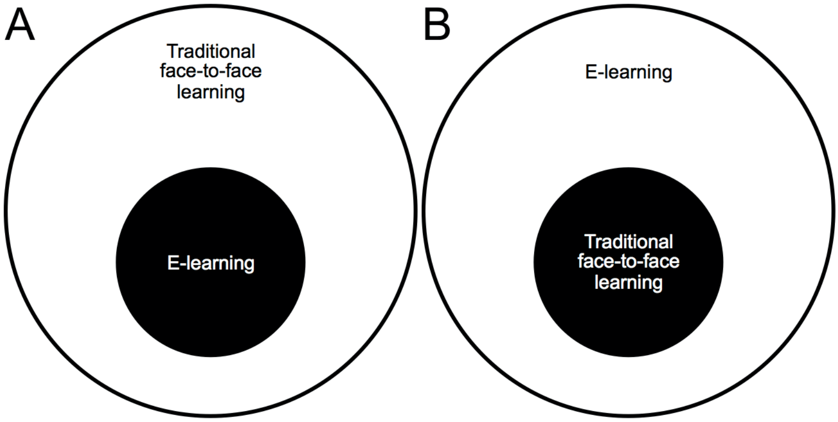


Figure 1.10. Stages of e-learning. (A) Present stage of e-learning: e-learning is used to supplement traditional face-to-face learning (traditional classroom approach, e.g. flipped classroom concept). **(B)** Future stage of e-learning: traditional face-to-face learning is used to supplement e-learning. Source: own work based on: M.J. Cox, Formal to informal learning with IT: research challenges and issues for e-learning. *Journal of Computer Assisted Learning, **29***, p. 100 (2013).

Irrespective of the type of strategy for using the Internet to support learning, theoreticians enumerate many benefits from e-learning[144]. The most

141. T. Wanner & E. Palmer, op. cit., p. 356.
142. A.M.F. Yousef, M.A. Chatti & U. Schroeder, A usability evaluation of a blended MOOC environment: an experimental case study. *International Review of Research in Open and Distributed Learning, **16***, p. 83 (2015).
143. M.J. Cox, op. cit., pp. 99-100.
144. M. Rani, R. Nayak & O.P. Vyas, An ontology-based adaptive personalized e-learning system, assisted by software agents on cloud storage. *Knowledge-Based Systems, **90***, p. 34 (2015).

important ones definitely include – as noticed by Liu, Lin and Lin[145] – giving equal educational opportunities, e.g. through ensuring that students from rural areas have access to educational resources that without the Internet are available only by students in the cities, as well as e.g. through eliminating the limitations of time and space of the traditional school, which is particularly useful for disabled students or students who experience problems in learning. Furthermore, Salehi, Shojaee and Sattar[146] underline that e-learning can be used at every stage of education and in all types of training (e.g. business-oriented). It thus seems that it can help learn both children and teenagers, and adults (the topic of the positive influence of TEL will be further developed in this chapter).

1.2.2. M-learning

M-learning, or mobile learning[147], evolved from the concept of e-learning[148]. It consists in the same as e-learning, the difference being that it is exclusively based on mobile devices (e.g. smartphones, portable computers, tablets[149])[150], in other words on tools freed from the limitations of the necessity to remain in a "permanent physical connection to cable networks"[151], as phrased by Ha and Kim. This explains the names of the first British educational projects in the area of m-learning: *Hand-e-learning* or *Learning2Go*[152]. M-learning is thus

145. E.Z.F. Liu, C.H. Lin & Y.H. Lin, E-tutors' teaching readiness in distance learning companion project in Taiwan. *Procedia – Social and Behavioral Sciences, 176*, p. 387 (2015).
146. H. Salehi, M. Shojaee & S. Sattar, op. cit., p. 64.
147. N. Pachler, B. Bachmair & J. Cook, *Mobile learning: structures, agency, practices*. New York – – Dordrecht – Heidelberg – London: Springer Science & Business Media, pp. 4-7 (2009).
148. I. Ha & C. Kim, op. cit., p. 4.
149. Ibidem, pp. 3-4.
150. J. Multisilta, Designing learning ecosystems for mobile social media. In: A.D. Olofsson & J.O. Lindberg (Eds.), *Informed design of educational technologies in higher education: enhanced learning and teaching* (pp. 273-274). Hershey: Information Science Reference (2012); R. Zeng & E. Luyegu, Mobile learning in higher education. In: A.D. Olofsson & J.O. Lindberg (Eds.), *Informed design of educational technologies in higher education: enhanced learning and teaching* (pp. 293-297). Hershey: Information Science Reference (2012); I.I. Mahazir, M.N. Norazah, D. Rosseni, A.R.A. Arif & C.R. Ridzwan, Design and development performance-based into mobile learning for TVET. *Procedia – Social and Behavioral Sciences, **174***, p. 1765 (2015).
151. I. Ha & C. Kim, op. cit., p. 4.
152. N. Pachler, B. Bachmair & J. Cook, *op. cit.*, p. 31.

supposed to help not only, as is the case in e-learning, eliminate the time and material barriers for learning, but also set learning free from institutional and formal spaces[153].

Analysing the history of TEL, Sharples[154] distinguishes three phases of the development of the concept of m-learning. These are:

- A focus on devices: this phase began in the mid 1990s and referred to the focus of experimental verifications of the educational usefulness of devices such as: PDAs, laptops, mobile/cell phones, e-books, classroom response systems, handheld computers, data logging devices and reusable learning objects[155].
- A focus on learning outside the classroom: this phase is nothing else but technologizing traditional concepts of learning outside the classroom, expressed in activities such as e.g. field trips, museum visits, professional updating, bite-sized learning and personal learning organisers. In this phase, the focus was on using mobile technologies to lead students out of the formal limitations of the space of an educational institution and direct them towards context sensitive learning (what is interesting, and amusing from the current perspective, one of the first m-learning projects was based on communication via the Short Message Service and called SMS-based learning)[156].
- A focus on the mobility of the learner: this third – and last – phase refers to the technological creation of the learning space, consisting in such an application of mobile technologies that the learner can be mobile and learn in many diverse spaces[157]. This understanding of m-learning is supposed to consist of three types of cognitive activities:
  - Context-sensitive learning: this type of activities is based on location-aware services, and is supposed to consist in providing the student with learning content in a mobile way, based on the tracked location of their mobile device. For example, when during a school trip a student is on the street and watches a building that their teacher points to, the device will display the most important information (and/or trivia) about this building and hints on further stages of sightseeing – developing their knowledge in a given respect. In this

153. I.I. Mahazir, M.N. Norazah, D. Rosseni, A.R.A. Arif & C.R. Ridzwan, op. cit., p. 1765.
154. N. Pachler, B. Bachmair & J. Cook, *op. cit.*, p. 30.
155. Ibidem, pp. 30-34.
156. Ibidem, pp. 34-41.
157. Ibidem, p. 41.

way, the reality of learning (the city visited in this case) starts to be augmented with a virtual dimension by mobile devices[158].

- Mixed reality learning (or mixed modes of representation, or augmented reality learning): this type of activities is very similar to the above-mentioned, however, it assumes not only providing the student with content based on the location of their mobile device, but also augmenting the fragment of reality perceived by this student with a visual virtual dimension. It is thus not only about providing content, but about adding, in real time, non-existing images over the space perceived (see Figure 1.11). Coming back to the previous example, the student will not only receive information about the building they

Figure 1.11. An example of activities of the mixed reality learning type. During a trip to the old castle in Kolding (Denmark), the student can see what its interior might have looked like in the past by pointing the tablet or smartphone to the right place. Visualizations are displayed in real time. Source: public domain; title: *Dansk: Kirkerummet pa Koldinghus, vist i Augmented Reality*; author: Charlotteshj.

158. Ibidem, pp. 44-46.

watch, but they will also see what it looked like in the past on their mobile devices, they will be able to see its interior or destroyed and non-existing elements of its façade added in real time to the building[159]. Mixed reality learning and context-sensitive learning can also be based on technologies other than location-aware services, e.g. on Quick Response (QR) codes. The learner then scans a QR code placed on the building using their mobile device, and automatically converts them into some content, visualization, film etc.[160].

- Ambient learning: this type of activities combines the two previous ones, showing, however, that any objects augmented by mobile technologies are not to be selected only but formalized subjects (e.g. teachers), but they are also supposed to be any objects from the student's surroundings. In this way, students' whole life and growth environment is supposed to be supported with content and visualizations[161]. As Perez-Sanagustin, Parra, Verdugo, Garcia-Galleguillos and Nussbaum[162] notice, this type of activities can thus be used to improve learning in any open spaces, especially open public spaces, such as public gardens, which is the fundamental observation for the considerations in this book.

To sum up the considerations on e-learning and m-learning, it is worth reminding the concept of multi-screen learning ecosystems, created by Kapenieks, Zuga, Gorbunovs, Jirgensons, Kapenieks Sr., Kapenieks Jr., Vitolina, Majore, Jakobsone-Snepste, Kudina, Kapenieks, Timsans, Gulbis, Tomsons, Ulmane-Ozolina, Letinskis and Balode[163]. This concept assumes that the devices used in e-learning and m-learning (those used in TV-learning/t-learning, i.e. TV sets, can also be taken into account here) create learning ecosystems,

159. Ibidem, pp. 41-44.
160. G.B. Hau, S. Siraj & N. Alias, Research and trends in the field of technology-enhanced learning from 2006 to 2011: a content analysis of Quick Response Code (QR-Code) and its application in selected studies. *Malaysian Online Journal of Educational Technology,* ***1***, pp. 55, 63 (2013).
161. N. Pachler, B. Bachmair & J. Cook, *op. cit.*, pp. 46-49.
162. M. Perez-Sanagustin, D. Parra, R. Verdugo, G. Garcia-Galleguillos & M. Nussbaum, Using QR codes to increase user engagement in museum-like spaces. *Computers in Human Behavior,* ***60***, pp. 73-74, 83 (2016).
163. A. Kapenieks, B. Zuga, A. Gorbunovs, M. Jirgensons, J. Kapenieks Sr., J. Kapenieks Jr., I. Vitolina, G. Majore, G. Jakobsone-Snepste, I. Kudina, K. Kapenieks, Z. Timsans, R. Gulbis, D. Tomsons, L. Ulmane-Ozolina, J. Letinskis & A. Balode, User behavior in multi-screen eLearning. *Procedia Computer Science,* ***65***, pp. 761-765 (2015).

characterized with the educational use of all types of ICT devices or screens that students have at hand. In the multi-screen learning ecosystems concept it is assumed that thanks to that students perceive educational activities as close to their everyday lives and shape an attitude directed at independent learning in themselves, as well as they develop an open attitude towards the rationality of life-long learning. Learning with the use of all available ICT tools also gives an opportunity to learn virtually everywhere, because every space becomes a space for learning. This is how the concept of ubiquitous learning is formed, which will be the topic of the next paragraph.

1.2.3. U-learning

Looi, Seow, Zhang, So, Chen and Wong[164] notice that "one of the fundamental challenges for the 21st century learners is not only what they learn, but also how and when they learn". These authors underline that in order to be able to face these challenges, the concept of ubiquitous learning (u-learning for short) should be introduced into education as a new stage of the TEL evolution, established by the ubiquitous nature of the contemporary mobile technologies (because they are personal, portable, wireless etc.)[165]. U-learning assumes that this ubiquitous nature of contemporary mobile technology makes it possible to learn virtually everywhere, and that students are surrounded with knowledge that they can gain through ICT tools implemented in their everyday lives[166]. When characterizing the u-learning environment, Ha and Kim[167] even observe that – although it is definitely a simplification that is slightly too big – at present "education is happening all around the student but the student may not even be conscious of the learning process. Source data is present in the embedded objects and students do not have to do anything in order to learn. They just have to be there".

Using the terminology by Zdravkova[168], u-learning can be called m-learning 2.0 – to a larger extent than in m-learning, in u-learning the emphasis is on the student to learn through discovery, with the use of mobile ICT tools that permeate every knowledge space of their lives. According to Boticki, Baksa,

164. C.-K. Looi, P. Seow, B.H. Zhang, H.-J. So, W. Chen & L.-H. Wong, op. cit., p. 155.
165. Ibidem.
166. I. Ha & C. Kim, op. cit., p. 4.
167. Ibidem.
168. K. Zdravkova, Reinforcing social media based learning, knowledge acquisition and learning evaluation. *Procedia – Social and Behavioral Sciences, **228***, p. 17 (2016).

Seow and Looi[169], in u-learning it is the student who decides "what, where, when and whether to learn" – each space and time conceals something that is worth learning, and each ICT tool provides us with an opportunity to learn, at least relatively, in an interesting way.

As underlined by Chai, Wong and King[170], one of the most important benefits of the educational application of u-learning is that students can learn "in the real world, which contributes to the authenticity of the learning". What is more, as indicated by Hsu and Hwang[171], students can explore real-time information. The results of many studies show[172] that such a situation (learning in the real world, with the use of real-time information) – which is another incredibly significant topic for analysis in this book – considerably increases learning achievements, learning efficiency and satisfaction from learning.

The above-mentioned Looi, Seow, Zhang, So, Chen and Wong[173] observe that at present u-learning evolves in the direction of the so-called seamless learning, a concept assuming that learning experience, thanks to the ubiquitous nature of contemporary mobile technology, can extend to all spaces (private and public) and contexts (in-school and after-school, formal and informal etc.). The idea of seamless learning is explained in an excellent way by its two characteristics expressed in numbers 24/7 and 1:1. 24/7 means that students have access to any type of learning content twenty-four hours a day, seven days a week. On the other hand, 1:1 refers to the fact that in order to access educational resources in such a situation, one student only needs one mobile device (of course a student can use more than one mobile ICT tool)[174]. By referring themselves to Hollan, Hutchins and Kirsch who formulated the idea of three principles in which cognitive processes occur, Looi, Seow, Zhang, So, Chen and Wong[175], define seamless learning as a process of building cognitive artefacts, mediated by ubiquitous ICT tools, and carried out both as individual learning and collaborative learning, as well as both in private learning spaces and public learning spaces, at the same time – though not permanently – with

169. I. Boticki, J. Baksa, P. Seow & C.-K. Looi, Usage of a mobile social learning platform with virtual badges in a primary school. *Computers & Education, **86***, p. 120 (2015).

170. C.S. Chai, L.-H. Wong & R.B. King, op. cit., p. 172.

171. C.-K. Hsu & G.-J. Hwang, A context-aware ubiquitous learning approach for providing instant learning support in personal computer assembly activities. *Interactive Learning Environments, **22***, p. 689 (2014).

172. Ibidem, pp. 687-689, 698.

173. C.-K. Looi, P. Seow, B.H. Zhang, H.-J. So, W. Chen & L.-H. Wong, op. cit., pp. 155-156.

174. C.S. Chai, L.-H. Wong & R.B. King, op. cit., p. 170.

175. C.-K. Looi, P. Seow, B.H. Zhang, H.-J. So, W. Chen & L.-H. Wong, op. cit., p. 156.

teachers or experts taking part directly or indirectly. Figure 1.12 presents this understanding of the seamless learning framework that constitutes the concept of smart learning, which is key to the considerations in this book, and which will be the topic of the next paragraph.

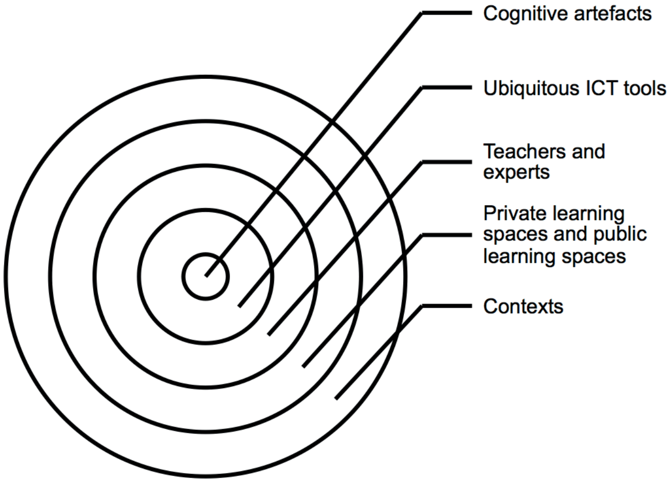


Figure 1.12. The seamless learning framework. Source: own work based on: C.-K. Looi, P. Seow, B.H. Zhang, H.-J. So, W. Chen & L.-H. Wong, Leveraging mobile technology for sustainable seamless learning: a research agenda. *British Journal of Educational Technology, **41***, p. 161 (2010).

1.2.4. Smart learning – towards smart education

Leahy, Davis, Lewin, Charania, Nordin, Orlic, Butler and Lopez-Fernadez[176] notice that currently the term *smart* is hugely popular. Most often, it is used with reference to various types of technological solutions that are aimed at improving various spheres of human life. In this context, Miller[177] enumerates for example smart aircraft, smart businesses, smart clothing, smart cars, smart home, smart medicine, smart shopping, smart television, smart warfare. However, one of the key, if not the most important, concepts developed around the world in the smart framework is that of a smart city. The smart city (this

176. M. Leahy, N. Davis, C. Lewin, A. Charania, H. Nordin, D. Orlic, D. Butler & O. Lopez-Fernadez, Smart partnerships to increase equity in education. *Journal of Educational Technology & Society, **19***, p. 84 (2016).
177. M. Miller, *The Internet of Things: how smart TVs, smart cars, smart homes, and smart cities are changing the world*. Indianapolis: Pearson Education (2015).

concept will be discussed in more detail in a separate paragraph in Chapter 3) refers to the technological transformation of cities in line with the needs of contemporary societies. It is a very broad system of thinking about technological growth that encompasses many subsystems, such as: transportation, energy, health care, buildings and – most importantly for the considerations in this book – learning[178]. The implementation of smart equipment in cities – as also underlined by Ha and Kim[179] – shapes the path towards smart learning, and, consequently, to smart education (this topic will be further developed in Chapter 3 of this book).

Smart learning, sometimes referred to as s-learning[180] (however, due to a number of concepts of learning that start with this letter, e.g. the above-mentioned seamless learning, this abbreviation may be confusing, thus it is very rarely used), is a new and still barely known educational paradigm, based on the assumptions of e-learning, m-learning and u-learning (including seamless learning). Yet, smart learning – as assumed by theoreticians – has larger technological requirements than those of the concepts that are its basis. As a minimum, it requires a 4G and Wi-Fi infrastructure, and not just the Wireless Internet (2/3G, Wireless Lan), as is the case in m-learning and u-learning, not to mention the wired Internet, characteristic of e-learning[181]. What is more, to apply smart learning it is not sufficient to have a mobile device with a good Internet connection (of the 4G type), but some kind of a smart device is necessary (see Figure 1.13)[182].

Even though it is assumed that from the perspective of the theory of learning smart learning is an approach easy to implement in the traditional system of education[183], in most countries of the world the existing learning infrastructure is – as observed by Kim, Song and Yoon[184] – still insufficient for this concept to enter the everyday lives of students.

Nevertheless, the smart learning concept continues to be technologically supplemented and its new, more technologically advanced versions are creat-

178. M. Leahy, N. Davis, C. Lewin, A. Charania, H. Nordin, D. Orlic, D. Butler & O. Lopez-Fernadez, op. cit., pp. 84-85.
179. I. Ha & C. Kim, op. cit., p. 1.
180. Ibidem, p. 4.
181. J. Lee, H. Zo & H. Lee, Smart learning adoption in employees and HRD managers. *British Journal of Educational Technology,* ***45***, p. 1084 (2014).
182. I. Ha & C. Kim, op. cit., p. 3.
183. Ibidem, p. 1.
184. S. Kim, S.-M. Song & Y.-I. Yoon, Smart learning services based on smart cloud computing. *Sensors,* ***11***, p. 7836 (2011).

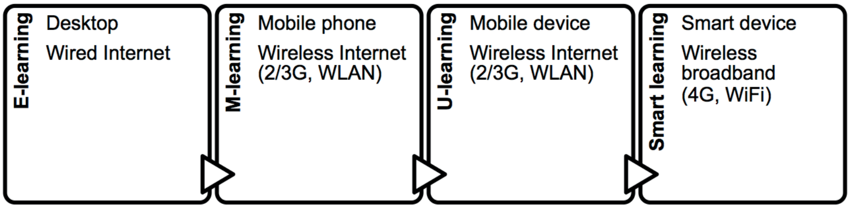


Figure 1.13. Technological requirements of e-learning, m-learning, u-learning as compared to smart learning. Source: own work based on: I. Ha & C. Kim, The research trends and the effectiveness of smart learning. *International Journal of Distributed Sensor Networks, **2014***, p. 3 (2014); J. Lee, H. Zo & H. Lee, Smart learning adoption in employees and HRD managers. *British Journal of Educational Technology, **45***, p. 1085 (2014).

ed[185]. An excellent example of this kind of activities is the attempt at making the idea of *moving to the cloud* real within smart learning, i.e. an idea of making learning independent from the material character of educational resources of knowledge[186]. In the future, smart learning is thus supposed to be carried out through smart cloud computing[187]. It is assumed, rather very surprisingly, however, that such a vision is only characteristic of the near future. In the more distant future, on the other hand, which may cause considerable educational anxiety, philosophers dealing with education and technology notice an opportunity to implement learning strategies in education that would be based on even more advanced technological solutions, such as gesture-based computing[188]. Such a vision, though, still has a structure of a transhumanistic vision (linked to cyborgization[189]), thus it is difficult to evaluate the power of its predictions and real educational sense[190].

The option to perceive smart learning from the perspective of the cybermatics concept – a broader vision of the Internet of Things (IoT), some-

185. N. Yusuf & N. Al-Banawi, op. cit., p. 176.
186. J. Sandars, Technology-enhanced learning. *Education for Primary Care, **24***, p. 300 (2013).
187. S. Kim, S.-M. Song & Y.-I. Yoon, op. cit., pp. 7836-7839.
188. J. Sandars, op. cit., pp. 300-301.
189. M. Klichowski, The twilight of education? Reflections on the concept of cyborgization. In: J. Pyzalski (Ed.), *Educational and socio-cultural competences of contemporary teachers. Selected issues* (pp. 45-55). Lodz: the Q studio (2015).
190. M. Klichowski, The end of education, or what do trans-humanists dream of. *Standard Journal of Educational Research and Essay, **3***, pp. 136-138 (2015); M. Klichowski, Transhumanism and the idea of education in the world of cyborgs. In: H. Krauze-Sikorska and M. Klichowski (Eds.), *The educational and social world of a child. Discourses of communication, subjectivity and cyborgization* (pp. 431-438). Poznan: Adam Mickiewicz University Press (2015).

times called hyper IoT[191], seems to be much closer to reality. As noticed by Ning, Liu, Ma, Yang and Huang[192], i.e. authors of the cybermatics concept, IoT "becomes an attractive system paradigm to realize universal interactions among the ubiquitous things through heterogeneous spaces. The future IoT is expected to be characterized by the comprehensive perception, reliable transmission, and intelligent processing to achieve pervasive interconnections, intelligence, and efficiency". Cybermatics, as a proposed hyper IoT, is supposed to be based on combining the elementary spaces of human development, such as cyberspace, physical space, social space and thinking space, through a network of objects. As a result, a cyber–physical–social–thinking hyperspace (CPST hyperspace)[193] is to be created. Smart learning perceived from the perspective of cybermatics would then mean learning through the CPST hyperspace, which is a very interesting point of reference for the considerations in this book.

By the way, even though this issue is not too crucial from the point of view of the analyses taken up in this book, it is worth mentioning that in the context of learning some theoreticians of learning also treat the term *smart* as an acronym referring to learning objectives. In the concept of smart learning, learning objectives are to be:

- **S**pecific.
- **M**easurable.
- **A**chievable.
- **R**elevant.
- **T**imed[194].

To sum up the considerations in this paragraph, it can thus be stated that smart learning is one of the latest stages of TEL, forming a basis for the concept of smart education. What is more, smart learning (and smart education) is a concept that develops and undergoes transformations all the time, and at the same time it matches the global trends of technological development of cities. This issue, only mentioned in this paragraph, will be discussed in more

191. H. Ning, H. Liu, J. Ma, L.T. Yang & R. Huang, Cybermatics: cyber–physical–social–thinking hyperspace based science and technology. *Future Generation Computer Systems, **56***, p. 505 (2016).
192. Ibidem, p. 504.
193. Ibidem, pp. 506-508.
194. T. Tofade, A. Khandoobhai & K. Leadon, Use of SMART learning objectives to introduce continuing professional development into the pharmacy curriculum. *American Journal of Pharmaceutical Education, **76***, p. 2 (2012).

detail in Chapter 3 of this book. It will also be unambiguously shown there that the concept of smart education becomes a basis for the idea of learning in CyberParks[195] developed in this book.

1.3. Technology-enhanced learning from the perspective of recent studies

It is commonly agreed that at present ICT change all human life dramatically[196]. To a lesser extent, they also change contemporary students' process of learning[197], or even – as underlined by Voogt, Knezek, Cox, Knezek and ten Brummelhuis[198] – their practical application leads to a fundamental modification of the entire landscape of contemporary education. However, Rooney[199] notices that still very little is known about what direction the learning process is diverted to by ICT. As noticed by Alemu[200], without doubt ICT create a new context of learning, yet we do not know at all whether TEL is actually effective and whether it brings about more positive effects than negative. Glover, Hepplestone, Parkin, Rodger and Irwin[201] claim that this is mainly because TEL has all the time been an uncommon phenomenon, and TEL strategies are mostly used by enthusiasts, i.e. people who are outstanding teachers, and who can apply any tool to bring about positive effects. What is more, Ha and

195. M. Klichowski, P. Bonanno, S. Jaskulska, C. Smaniotto Costa, M. de Lange & F. Klauser, op. cit., pp. 3-5.
196. P. Rooney, Facilitating online continuing professional development opportunities in technology-enhanced learning: the TELTA approach. *International Journal of Advanced Corporate Learning, **8***, p. 39 (2015).
197. S. Amuko, M. Miheso & S. Ndeuthi, Opportunities and challenges: integration of ICT in teaching and learning mathematics in secondary schools, Nairobi, Kenya. *Journal of Education and Practice, **6***, p. 1 (2015).
198. J. Voogt, G. Knezek, M. Cox, D. Knezek & A. ten Brummelhuis, Under which conditions does ICT have a positive effect on teaching and learning? A call to action. *Journal of Computer Assisted Learning, **29***, p. 1 (2013).
199. P. Rooney, op. cit., pp. 39.
200. B.M. Alemu, Integrating ICT into teaching-learning practices: promise, challenges and future directions of higher educational institutes. *Universal Journal of Educational Research, **3***, pp. 170-171 (2015).
201. I. Glover, S. Hepplestone, H.J. Parkin, H. Rodger & B. Irwin, Pedagogy first: realising technology enhanced learning by focusing on teaching practice. *British Journal of Educational Technology, **47***, pp. 993-994 (2016).

Kim[202] clearly show that there are very few solid, and in particular experimental, studies into TEL.

An excellent exemplification of this issue can be the aspect of diverse competences shaped by TEL. Many researchers manifest it that TEL contributes to the development of 21st-century skills, such as critical thinking, creativity, communication, collaboration[203], as well as problem solving and innovation[204]. In this context, it is creativity that is most underlined, and its increase as a result of applying TEL is also reported by some research (also in reference to the so-called flow experience[205])[206]. Nevertheless, studies by Barak and Levenberg[207] show that in order to be able to use TEL effectively, students' flexible thinking needs to be very developed, i.e. they have to be capable of, among others, creative thinking, critical thinking and problem solving. What is more, many other studies[208] show that TEL requires students to carry out very advanced metacognitive processes, thus obliging them to be highly capable of regulating their own cognition (metacognition is sometimes defined as "cognition about cognition", which excellently illustrates the meaning of this notion[209]). In addition, as shown by a number of further studies[210], TEL is attractive main-

202. I. Ha & C. Kim, op. cit., p. 1.
203. M. Qian & K.R. Clark, Game-based learning and 21st century skills: a review of recent research. *Computers in Human Behavior,* ***63***, p. 53 (2016).
204. J. Nasongkhla & S. Sujiva, Teacher competency development: teaching with tablet technology through classroom innovative action research (CIAR) coaching process. *Procedia – Social and Behavioral Sciences,* ***174***, pp. 992-993 (2015).
205. L. Nijs, B. Moens, M. Lesaffre & M. Leman, The music paint machine: stimulating self-monitoring through the generation of creative visual output using a technology-enhanced learning tool. *Journal of New Music Research,* ***41***, pp. 79, 98 (2012).
206. Y.-T.C. Yang, Virtual CEOs: a blended approach to digital gaming for enhancing higher order thinking and academic achievement among vocational high school students. *Computers & Education,* ***81***, pp. 281, 290-293 (2015).
207. M. Barak & A. Levenberg, Flexible thinking in learning: an individual differences measure for learning in technology-enhanced environments. *Computers & Education,* ***99***, pp. 39-41, 49 (2016).
208. A. Raes, T. Schellens, B. De Wever & D.F. Benoit, Promoting metacognitive regulation through collaborative problem solving on the web: when scripting does not work. *Computers in Human Behavior,* ***58***, pp. 325-326, 335-336 (2016).
209. M. Bannert, C. Sonnenberg, C. Mengelkamp & E. Pieger, Short- and long-term effects of students' self-directed metacognitive prompts on navigation behavior and learning performance. *Computers in Human Behavior,* ***52***, p. 294 (2015).
210. A.L. Goodwin, E.L. Low, P.T. Ng, A.S. Yeung & L. Cai, Enhancing playful teachers' perception of the importance of ICT use in the classroom: the role of risk taking as a mediator. *Australian Journal of Teacher Education,* ***40***, pp. 132-149 (2015); A. Padilla-Melendez,

ly for cognitively playful persons, i.e. individuals who are capable of, among others, experimenting and applying various tools in an unconventional way. It is therefore visible that one cannot be sure if TEL effectively shapes given competences in each student's case or if it only emphasizes them in certain students who are particularly skilled or developed as far as these competencies are concerned. What is more, it can be seen that results of many studies into TEL are often contradictory.

In the following paragraphs, results of research into TEL will be reconstructed. They will be organised in two groups: results showing a positive influence of TEL and results showing a negative influence of TEL. Afterwards, results of the latest research into the need to personalize TEL and conduct research in the context of TEL using the paradigms of cognitive neuroscience and psychophysiology will be presented. In this way, the complexity of assessing the effectiveness of TEL will be highlighted and a methodologically optimum approach to TEL research will be outlined.

1.3.1. Selected recent studies and a positive influence of technology-enhanced learning

Research results by Porta, Mas-Machuca, Martinez-Costa and Maillet [211] demonstrate that educational experts most often have a very positive attitude towards TEL. These experts notice that TEL increases students' motivation to learn and at the same time it gives them an opportunity to learn according to their own cognitive rhythm[212]. As shown by Figure 1.14, using TEL in one's teaching practice mostly stems from the fact that TEL is perceived as a strategy that increases positive learning results, provides students with an opportunity to have access to the latest technologies, but also makes detailed self-evaluation and remote learning, freed from time usurpation, possible for them.

To a certain degree, such a positive approach to TEL is reflected in the results of research into not just opinions on TEL, but real effects of this pro-

A. Aguila-Obra & A. Garrido-Moreno, Perceived playfulness, gender differences and technology acceptance model in a blended learning scenario. *Computers & Education,* ***63***, pp. 306-317 (2013); J.P.-L. Tan & E. McWilliam, From literacy to multiliteracies: diverse learners and pedagogical practice. *Pedagogies: An International Journal, **4***, pp. 213-225 (2009).

211. M. Porta, M. Mas-Machuca, C. Martinez-Costa & K. Maillet, op. cit., p. 63.

212. Ibidem, p. 56.

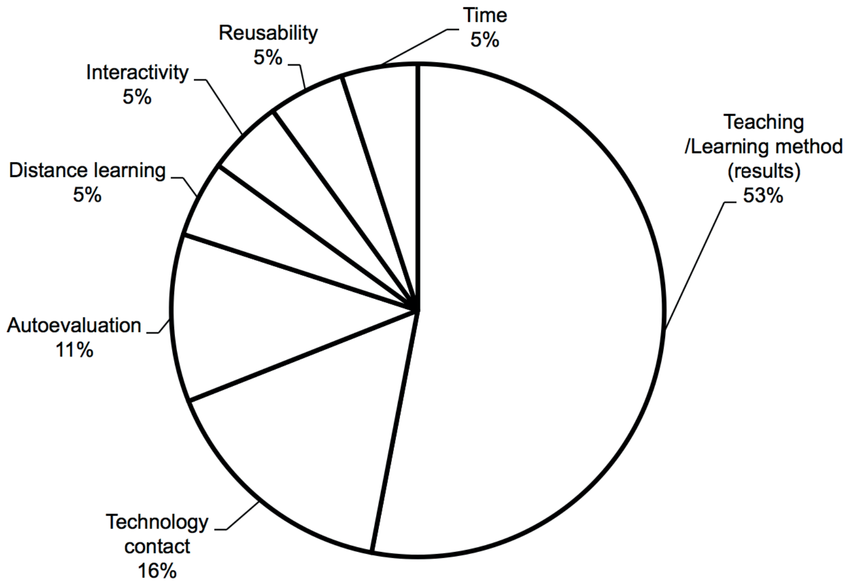


Figure 1.14. Feedback from education experts on their reasons for using technology-enhanced learning in the process of learning. Source: own work based on: M. Porta, M. Mas-Machuca, C. Martinez-Costa & K. Maillet, A Delphi study on technology enhanced learning (TEL) applied on computer science (CS) skills. *International Journal of Education and Development using Information and Communication Technology,* ***8***, p. 56 (2012).

cess[213]. For example, Boticki, Baksa, Seow and Looi[214] created a mobile learning platform called SamEx that made it possible for pupils at a primary school to learn cooperatively, share electronic materials and discuss or ask questions about the topics covered at school and their own interests. After a year of the

213. T. de Jong, A. Weinberger & I. Girault, Using scenarios to design complex technology-enhanced learning environments. *Educational Technology Research and Development,* ***60***, p. 884 (2012); M. Porta, M. Mas-Machuca, C. Martinez-Costa & K. Maillet, op. cit., p. 48; C.M. Barrette, Usefulness of technology adoption research in introducing an online workbook. *System,* ***49***, pp. 133-134 (2015); H.-Y. Chang, C.-Y. Wang, M.-H. Lee, H.-K. Wu, J.-C. Liang, S.W.-Y. Lee, G.-L. Chiou, H.-C. Lo, J.-W. Lin, C.-Y. Hsu, Y.-T. Wu, S. Chen, F.-K. Hwang & C.-C. Tsai, A review of features of technology-supported learning environments based on participants' perceptions. *Computers in Human Behavior,* ***53***, p. 223 (2015); H. Salehi, M. Shojaee & S. Sattar, op. cit., p. 63; M. Siadaty, D. Gasevic & M. Hatala, Associations between technological scaffolding and micro-level processes of self-regulated learning: a workplace study. *Computers in Human Behavior,* ***55***, p. 1008 (2016); A. Tlili, F. Essalmi, M. Jemni, Kinshuk & N.-S. Chen, op. cit., p. 806.
214. I. Boticki, J. Baksa, P. Seow & C.-K. Looi, op. cit., pp. 122-123.

experiment, it turned out that pupils using SamEx achieved better results in learning than those who didn't use SamEx[215].

On the other hand, Wu, Hsu and Hwang[216] prepared a specialist programme for modelling natural phenomena, used in science education on the secondary school level. In its experimental phase, the programme was used to model phenomena linked to air pollution, thus its working title was the Air Pollution Modeling Tool (APoMT). The researchers conducted five learning lessons with the use of APoMT. It turned out that the use of APoMT led to a significant improvement in conceptual understandings[217].

Other research proved that e-lessons implemented in the integrated virtual learning environment platform (IVLE)[218], as well as keeping e-portfolios by learners[219] both make it possible for students to have better control over their learning[220]. What is more, as indicated by Kim and Jang's analyses[221], introducing tablets in schools in rural areas builds a conviction among students about their capability of achieving success in the future and increases their general perception of the effectiveness of learning. Furthermore, several studies showed that TEL also brings about positive (in a sense, unintentionally added) effects as far as general education is concerned. For example, Choudhury, Venkatesh, Bhattacharya and Sarma[222] noticed that in classes consisting of many pupils where the computer system called Avabodhaka, designed to send educational materials among pupils and teachers, tested by these researchers was used, interactions among all the participants of the learning process were

215. Ibidem, p. 136.
216. H.-K. Wu, Y.-S. Hsu & F.-K. Hwang, Designing a technology-enhanced learning environment to support scientific modeling. *Turkish Online Journal of Educational Technology – TOJET,* ***9***, pp. 58-60 (2010).
217. Ibidem, p. 63 (2010).
218. S. Gautam, Z. Qin & K.C. Loh, Enhancing laboratory experience through e-lessons. *Education for Chemical Engineers,* ***15***, pp. 19-20 (2016).
219. A.E. Yastibas & G.C. Yastibas, The use of e-portfolio-based assessment to develop students' self-regulated learning in English language teaching. *Procedia – Social and Behavioral Sciences,* ***176***, pp. 4-6 (2015); L. Ellis & J.-A. Kelder, Individualised marks for group work: embedding an ePortfolio criterion in a criterion referenced assessment (CRA) rubric for group-work assessment. *Education for Information,* ***29***, pp. 219-227 (2012).
220. S. Gautam, Z. Qin & K.C. Loh, op. cit., p. 22; A.E. Yastibas & G.C. Yastibas, op. cit., p. 10.
221. H.J. Kim & H.Y. Jang, Factors influencing students' beliefs about the future in the context of tablet-based interactive classrooms. *Computers & Education,* ***89***, pp. 1-3 (2015).
222. N. Choudhury, T. Venkatesh, S. Bhattacharya & S. Sarma, Avabodhaka: a system to analyse and facilitate interactive learning in an ICT based system for large classroom. *Procedia Computer Science,* ***84***, pp. 160-162, 167 (2016).

considerably improved. On the other hand, Ioannou and Antoniou[223] proved that in a conflict situation among young children from the same class they can be reconciled very effectively by using multitouch interactive tables, i.e. tables whose top is a huge tablet. As shown in Figure 1.15, those researchers proved that playing games together at such a table contributes to effective problem-solving and shaping general good relations in a school class.

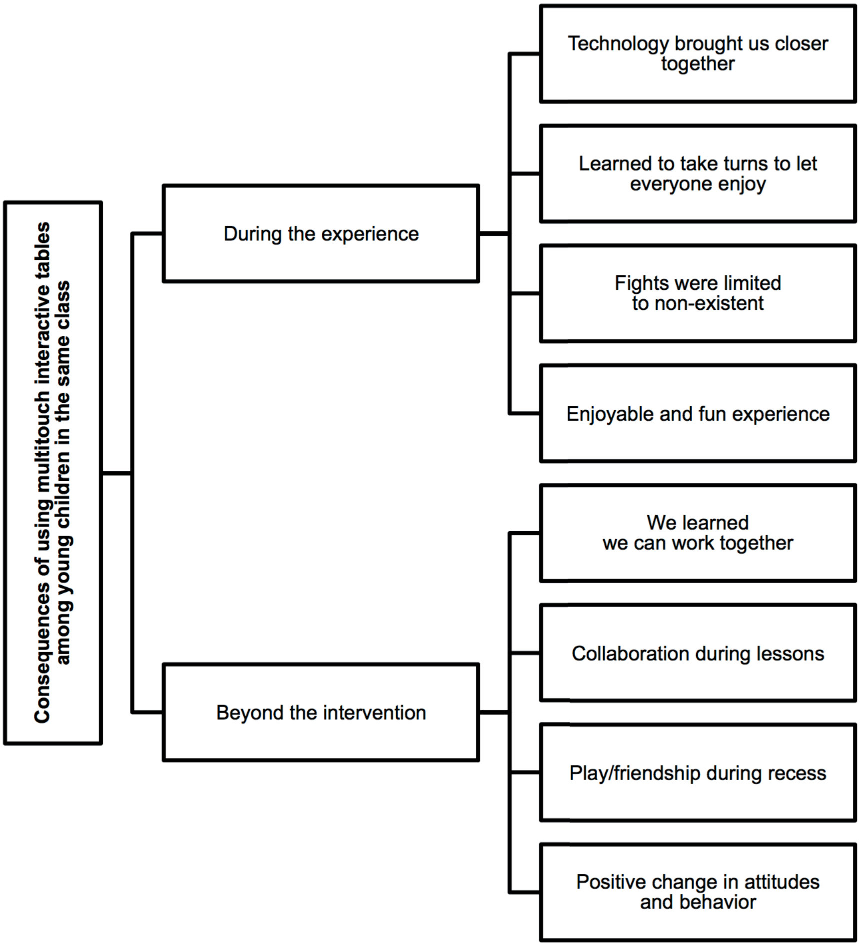


Figure 1.15. Consequences of using multitouch interactive tables among young children in the same class. Source: own work based on: A. Ioannou & C. Antoniou, Tabletops for peace: technology enhanced peacemaking in school contexts. *Journal of Educational Technology & Society*, ***19***, p. 171 (2016).

223. A. Ioannou & C. Antoniou, Tabletops for peace: technology enhanced peacemaking in school contexts. *Journal of Educational Technology & Society*, ***19***, pp. 173-175 (2016).

It is also worth underlining that there are research results showing positive "extra-mural" effects of TEL. These include, among others:

- Research into the use of TEL at workplace: the concept using TEL at workplace, called TEL@work (sometimes also technology-mediated workplace learning[224]), is very widespread, because most contemporary companies take up permanent action in the area of training their employees and at the same time seeking a strategy to decrease the cost of such training[225]. What is more, research by Arh, Blazic and Dimovski[226] demonstrates that TEL@work supports the consolidation of the social structure of employees and stimulates smooth transfer of knowledge among them. As the authors claim, it is also a very flexible strategy, adjusting to employees' diverse needs and in itself it is characterized by a high ecology rate. The results of analyses by Siadaty, Gasevic and Hatala[227] indicate, however, that TEL@work gives employees a chance for incredibly effective self-learning, which at the same time does not require the company to go to great financial expenses. Figure 1.16 illustrates one of the most popular models of TEL@work environments. It is also worth adding that – as explained by Goggins's research[228] – TEL@work becomes an opportunity for companies located in small towns, because through TEL@work employees develop competencies that let them cooperate with organizations from other locations or cities.
- Research into using TEL by adults over 65: the idea of using TEL by adults over 65 is above all linked to the fact that – as demonstrated by the analyses by Gustafson Sr., McTavish, Gustafson Jr., Mahoney, Johnson, Lee, Quanbeck, Atwood, Isham, Veeramani, Clemson and Shah[229] – contemporary people live longer and longer and they want to remain independent for a longer time. They thus need knowledge that

224. S.P. Goggins, Designing computer-supported collaborative learning at work for rural IT workers: learning ensembles and geographic isolation. *British Journal of Educational Technology, **45***, p. 1070 (2014).
225. P. Tynjala, P. Hakkinen & R. Hamalainen, TEL@work: toward integration of theory and practice. *British Journal of Educational Technology, **45***, pp. 990-992 (2014).
226. T. Arh, B.J. Blazic & V. Dimovski, op. cit., p. 379.
227. M. Siadaty, D. Gasevic & M. Hatala, op. cit., p. 1016.
228. S.P. Goggins, op. cit., pp. 1070-1071, 1076-1079.
229. D.H. Gustafson Sr., F. McTavish, D.H. Gustafson Jr., J.E. Mahoney, R.A. Johnson, J.D. Lee, A. Quanbeck, A.K. Atwood, A. Isham, R. Veeramani, L. Clemson & D. Shah, The effect of an information and communication technology (ICT) on older adults' quality of life: study protocol for a randomized control trial. *Trials, **16***, p. 2 (2015).

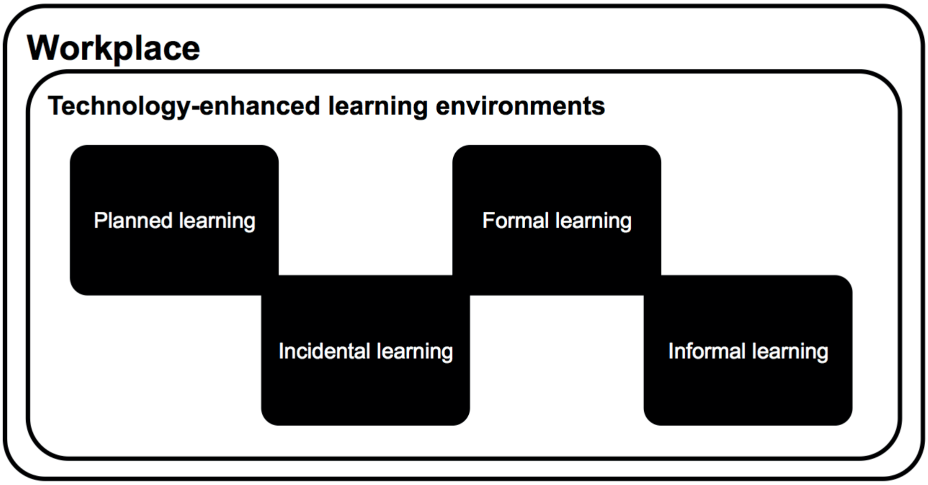


Figure 1.16. Model environments of technology-enhanced learning at workplace. Source: own work based on: M.K. Kim, Technology-enhanced learning environments to solve performance problems: a case of a Korean company. *TechTrends: Linking Research & Practice to Improve Learning*, ***55***, p. 38 (2011).

is fresh and passed on in an accessible way in order to be able to tackle the challenges of contemporary world on their own. At the same time, however, most countries – as indicated by this team of researchers – do not assign too much of their budgets to training senior citizens. In this context, TEL seems to be a good solution for them. This is confirmed by, among others, research results by Gonzalez, Ramirez and Viadel[230] which show that for adults over 65 it is sufficient to have a 20-hour course to be able to effectively and very cheaply learn through various ICT tools.

– Research into using TEL by the ill: using ICT by the ill is an idea that currently undergoes incredible development, linked to i.e. research areas such as telemedicine, e-health and connected health[231]. Such a form of applying ICT is mainly directed at improving the quality of life for

230. A. Gonzalez, M.P. Ramirez & V. Viadel, ICT learning by older adults and their attitudes toward computer use. *Current Gerontology and Geratrics Research*, ***8***, pp. 1, 5 (2015).
231. N. Mountford, T. Kessie, M. Quinlan, R. Maher, R. Smolders, P. Van Royen, I. Todorovic, H. Belani, H. Horak, I. Ljubi, J. Stage, D. Lamas, I. Shmorgun, M. Perala-Heape, M. Isomursu, V. Managematin, V. Trajkovik, A. Madevska-Bogdanova, R. Stainov, I. Chouvarda, G. Dimitrakopoulos, A. Stulman, P. Haddad, R. Alzbutas, N. Calleja, M. Tilney, A. Moen, E. Thygesen, R. Lewandowski, M. Klichowski, P. Oliveira, J. Machado da Silva, T. Loncar Turukalo, B. Marovic, K. Drusany Staric, B. Cvetkovic, E. Luque, L. Fernandez Luque,

people experiencing various types of health issues and permanently monitoring the state of their bodies, in order to minimize the progress of their illness and its consequences, or an escalation of growth disorders. Viewed from this perspective, TEL itself becomes a strategy for gaining knowledge about one's illness or allowing to create activities of preventive character[232]. It is worth noticing, however, that – as underlined by analyses conducted by Gandhi[233] – TEL based on open resources can also lead to a state of being lost or hypochondria due to the abundance of unreliable descriptions of symptoms, etiologies or course of many illnesses available on the Internet. Another context at this point is that of using TEL by the disabled. For example, many experimental[234] studies and meta-analyses[235] report that technology-based interventions bring very positive effects when working with children with autism. Studies by Striem-Amit, Cohen, Dehaene and Amedi[236] show, however, that TEL based on sensory substitution devices (SSDs) can stimulate positive neuroplastic changes (adaptive or/and compensatory) in visual pathways in the brain of the blind. Figure 1.17 shows that Alfaro, Bernabeu, Agullo, Parra and Fernandez[237] – by using the Diffusion Tensor Imaging (DTI) method – observed a similar effect in people suffering from achromatopsia (i.e. in colour-blind people) who used SSD of the visual-to-auditory prosthetic device called Eyeborg type. In a nutshell,

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S. Burmaoglu, N. Dolu, V. Curcin, J. McLaughlin & B. Caulfield, *Connected health in Europe: where are we today?* Dublin: University College Dublin (2016).

232. M. Raymond, S. Illiffe & J. Pickett, Technology-enhanced learning. *Education for Primary Care, **24***, pp. 148-149 (2013).

233. H. Gandhi, Technology-enhanced learning. *Education for Primary Care, **23***, pp. 308-309 (2012).

234. B.O. Ploog, A. Scharf, D. Nelson & P.J. Brooks, Use of computer-assisted technologies (CAT) to enhance social, communicative, and language development in children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, **43***, pp. 301–322 (2013); S. Parsons, Learning to work together: designing a multi-user virtual reality game for social collaboration and perspective-taking for children with autism. *International Journal of Child-Computer Interaction, **6***, pp. 28-38 (2015).

235. O. Grynszpan, P.L.T. Weiss, F. Perez-Diaz & E. Gal, Innovative technology-based interventions for autism spectrum disorders: a meta-analysis. *Autism, **18***, pp. 346–361 (2014).

236. E. Striem-Amit, L. Cohen, S. Dehaene & A. Amedi, Reading with sounds: sensory substitution selectively activates the visual word form area in the blind. *Neuron, **76***, pp. 641-645 (2012).

237. A. Alfaro, A. Bernabeu, C. Agullo, J. Parra & E. Fernandez, Hearing colors: an example of brain plasticity. *Frontiers in Systems Neuroscience, **9***, pp. 5-7 (2015).

Eyeborg allows colours to be perceived as sounds. These changes, resulting from learning colour sounds with this tool, led Eyeborg users to create a feeling of real perception of colours.

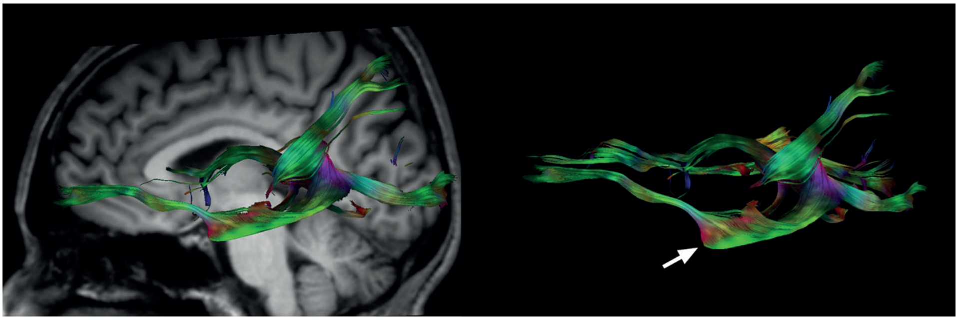


Figure 1.17. Neuroplastic changes among Eyeborg users suffering from achromatopsia. The subjects used sensory substitution devices of the visual-to-auditory prosthetic device type called Eyeborg for a minimum of eight years. Eyeborg makes it possible to hear colours. Changes in the visual pathways in the brain observed in the results of Diffusion Tensor Imaging led to creating a feeling of real perception of colours in Eyeborg users. The arrow points to the region with positive neuroplastic changes. Source: A. Alfaro, A. Bernabeu, C. Agullo, J. Parra & E. Fernandez, Hearing colors: an example of brain plasticity. *Frontiers in Systems Neuroscience,* ***9***, p. 7 (2015). Under the terms of the Creative Commons Attribution License.

1.3.2. Selected recent studies and a negative influence of technology-enhanced learning

Tenekeci[238] notices that the practical application of TEL in the educational reality which introduces numerous improvements both for pupils and teachers many times leads to the creation of a lot of diverse pedagogical hindrances. This view is shared by meta-analyses conducted by Tlili, Essalmi, Jemni, Kinshuk and Chen[239], yet these research results also underline that TEL can bring about negative effects in learning, too. According to Kruger and Blignaut[240], one of the reasons for such a situation is the fact that very often ICT lead pupils to feel stress, negative emotions, anxiety or simply repeated irritation.

238. E.H. Tenekeci, Preliminary study for technology enhanced learning: comparative study of England and Northern Cyprus. *Turkish Online Journal of Educational Technology – – TOJET,* ***10***, p. 300 (2011).
239. A. Tlili, F. Essalmi, M. Jemni, Kinshuk & N.-S. Chen, op. cit., p. 806.
240. J. Kruger & A.S. Blignaut, Linking emotional intelligence to achieve technology enhanced learning in higher education. *Turkish Online Journal of Distance Education,* ***14***, p. 100 (2013).

The meta-analyses carried out by D'Mello[241] indicate that it is mainly various discrete affective states, for example boredom, confusion and frustration, that occur here. The emotional layer is, on the other hand, a key context for building learning effects, and due to this, negative states and tensions lead to decreased TEL effects (for example, good attitude, satisfaction or balanced motivation favour positive effects of learning). Wanner and Palmer's[242] research results show that due to this pupils most often prefer to learn with very little support for this process stemming from ICT – and if they are to learn through TEL, they mostly prefer to choose such forms of TEL as (the above-mentioned) flipped classroom and blended learning.

The situation is similar among teachers. As shown by analyses by Kehrwald and McCallum[243], TEL still causes high levels of anxiety among teachers. Because of that – like pupils – they most often prefer to minimize the use of ICT in their practice and tend to select – as proved by Almpanis's[244] studies – – such types of TEL as blended learning. Paradoxically, as shown by Siggins and Flood[245] in their experiment, contemporary adults experience high levels of anxiety caused by a situation that in a sense is totally opposite, i.e. a sudden separation from one's personal smartphone.

While analyzing the relation between broadly understood stress and the use of ICT, it is possible to observe a certain type of a vicious circle. On the one hand – as underlined above – ICT tools cause certain stress, on the other hand, however – as demonstrated by Asakawa, Muramatsu, Hayashi, Urata, Taya and Mizuno-Matsumoto[246] – the higher the level of stress, the worse the human brain processes the content coming from ICT tools. Figure 1.18 shows that those researchers tested the level of stress using The State Trait Anxiety Inventory (STAI) among twenty-three healthy persons. They then divided the subjects into two groups: a low-anxiety group and a high-anxiety group. All the participants of the study sat in front of a smartphone and watched

241. S. D'Mello, A selective meta-analysis on the relative incidence of discrete affective states during learning with technology. *Journal of Educational Psychology, **105***, p. 1093 (2013).
242. T. Wanner & E. Palmer, op. cit., pp. 354, 364-366.
243. B.A. Kehrwald & F. McCallum, op. cit., p. 54.
244. T. Almpanis, op. cit., p. 386.
245. M. Siggins & C. Flood, Mobile phone separation and anxiety. In: A. Power & G. Kirwan (Eds.), *Cyberpsychology and new media: a thematic reader* (pp. 45-47). London – New York: Psychology Press (2014).
246. T. Asakawa, A. Muramatsu, T. Hayashi, T. Urata, M. Taya & Y. Mizuno-Matsumoto, Comparison of EEG propagation speeds under emotional stimuli on smartphone between the different anxiety states. *Frontiers in Human Neuroscience, **8***, p. 7 (2014).

emotional audio-visual and sentence stimuli[247]. Participants "viewed relaxing pictures such as landscapes in the resting session, funny pictures such as animals in the pleasant session, and terror pictures such as horror movies in the unpleasant session. In the emotional sentence stimuli sessions, participants viewed funny sentences found in email as pleasant sentence stimuli, and anxiety-provoking sentences from email as the unpleasant sentence stimuli"[248]. Researchers analyzed information processing through electroencephalography (EEG) propagation speed analysis in the alpha (8-14 Hz) band for these emotional stress stimuli. It turned out that the higher the level of stress in an individual, the worse the brain processing of information coming from the smartphone and the more panicky the reactions to unpleasant stimuli[249]. Thus, the vicious circle mentioned consists in the fact that ICT tools used in TEL cause or increase the level of stress among learners, and the effectiveness of TEL varies in direct proportion to the level of stress.

Interestingly, D'Mello's research[250] shows that higher levels of anxiety, boredom and frustration are registered in the context of TEL studied in research laboratories. When TEL is studied in an authentic learning context, for example in a school classroom, these negative states do not reach such drastically high levels. At the same time, Brown, Zeidman, Smittenaar, Adams, McNab, Rutledge and Dolan[251] prove that at present, the smartphone becomes an excellent research tool for cognitive science, allowing for rapid, large-scale experimentation and data collection, but only when research is conducted out of the laboratory, in an environment that is natural for a given type of activity.

Short's analyses[252] further underline that TEL is ineffective due to the fact that a phenomenon of decreased trust occurs in any interactions mediated by ICT. Trust is a key condition for the correct course of the process of learning with other pupils and teacher/teachers. Its decrease in TEL is mainly caused by limited face-to-face contacts, as well as various technological problems that build a general feeling of threat. Another condition for positive

247. Ibidem, pp. 2-4.
248. Ibidem, p. 2.
249. Ibidem, pp. 4-7.
250. S. D'Mello, op. cit., p. 1093.
251. H.R. Brown, P. Zeidman, P. Smittenaar, R.A. Adams, F. McNab, R.B. Rutledge & R.J. Dolan, Crowdsourcing for cognitive science – the utility of smartphones. *PLoS ONE, **9***, p. 1 (2014).
252. H. Short, A critical evaluation of the contribution of trust to effective technology enhanced learning in the workplace: a literature review. *British Journal of Educational Technology, **45***, pp. 1016-1017, 1020 (2014).

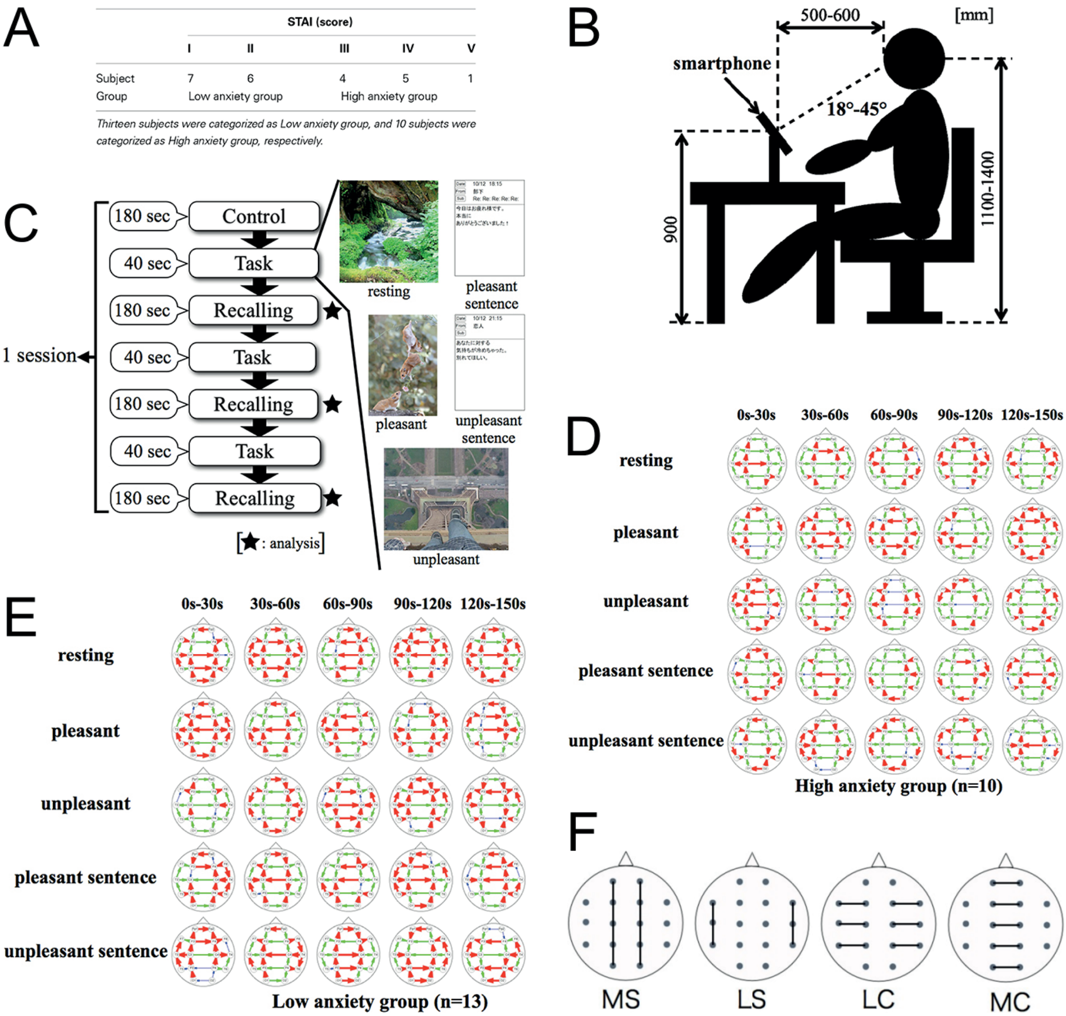


Figure 1.18. The course and results of an experiment on the relations between the level of stress and effectiveness of processing content coming from ICT tools in the human brain. **(A)** Using The State Trait Anxiety Inventory, the subjects were divided into two groups: a low-anxiety group and a high-anxiety group. **(B)** The subjects sat in front of a smartphone and **(C)** watched emotional audio-visual and sentence stimuli. **(D)** With the use of electroencephalography, it was diagnosed that individuals showing a higher level of stress are worse at processing information coming from their smartphone in their brains and have much more panicky reactions to unpleasant stimuli, **(E)** as compared to persons showing a lower level of stress. **(F)** Evaluating regions of propagation speed: medial sagittal (MS), lateral sagittal (LS), lateral coronal (LC), medial coronal (MC). Source: T. Asakawa, A. Muramatsu, T. Hayashi, T. Urata, M. Taya & Y. Mizuno-Matsumoto, Comparison of EEG propagation speeds under emotional stimuli on smartphone between the different anxiety states. *Frontiers in Human Neuroscience*, ***8***, pp. 3-5 (2014). Under the terms of the Creative Commons Attribution License.

effects of learning is good night's sleep. Research by Christensen, Bettencourt, Kaye, Moturu, Nguyen, Olgin, Pletcher and Marcus [253] show, however, that screen-time is associated with poor sleep. People who use a lot of ICT tools, for example smartphones, particularly around bedtime, sleep much worse. Learning through ICT tools – a fundamental concept in TEL – can thus decrease the effectiveness of sleep, and as a consequence, the effectiveness of learning itself.

In addition, the digitization of learning materials itself can decrease its effects. For example, Dalton, Connolly and Palmer[254] ran two equal classes in two groups of students. In the first one, students used multimedia-based learning materials, whereas in the other – paper-based. It turned out that the group using traditional paper resources and not using any forms of TEL scored better results.

1.3.3. Selected recent studies and the need to personalize technology-enhanced learning

Meta-analyses conducted by Tlili, Essalmi, Jemni, Kinshuk and Chen[255] show that the broadly understood effectiveness of TEL depends on a learner's personality to a very significant extent. What is more, experiments by Scott, Rodriguez, Soria and Campo[256] demonstrate that its key elements in this context are learning preferences, and learning styles in particular. For example, Hwang, Chiu and Chen[257] discovered that TEL based on multimedia games "significantly improved the students' learning achievements, learning motivations, satisfaction degree and flow state, in particular, for those active learning style students". According to those researchers, such a form of TEL is thus "more

253. M.A. Christensen, L. Bettencourt, L. Kaye, S.T. Moturu, K.T. Nguyen, J.E. Olgin, M.J. Pletcher & G.M. Marcus, Direct measurements of smartphone screen-time: relationships with demographics and sleep. *PLoS ONE*, ***11***, pp 1-14 (2016).

254. G. Dalton, I. Connolly & M. Palmer, Capturing lectures: using multimedia lecture captures to promote learning. In: A. Power & G. Kirwan (Eds.), *Cyberpsychology and new media: a thematic reader* (pp. 185, 190-193). London – New York: Psychology Press (2014).

255. A. Tlili, F. Essalmi, M. Jemni, Kinshuk & N.-S. Chen, op. cit., pp. 805-806, 811.

256. E. Scott, G. Rodriguez, A. Soria & M. Campo, Towards better Scrum learning using learning styles. *Journal of Systems and Software*, ***111***, pp. 249-252 (2016).

257. G.-J. Hwang, L.-Y. Chiu & C.-H. Chen, A contextual game-based learning approach to improving students' inquiry-based learning performance in social studies courses. *Computers & Education*, ***81***, p. 23 (2015).

beneficial to those active style students who tend to learn by doing, than to the reflective style learners"[258]. On the other hand, by using the Silverman learning style model, Khenissi, Essalmi, Jemni, Kinshuk, Graf and Chen[259] discovered that some forms of TEL (for example those using simulations) are more effective for pupils with global and intuitive learning styles who like, among others, innovations and problem solving, and other forms (for example those using logical tasks) are more effective for those with sequential and sensing learning styles, i.e. who do not enjoy novelties and surprises, and prefer linear, or even traditional, presentation of learning content.

Many researchers thus suggest that ICT tools used in TEL should monitor the learner's actual learning style and simultaneously adjust to it[260]. They underline the need to personalize TEL, both in the form of TEL and the learning content. However, many contemporary studies show that learning preferences, and/or learning styles, are a myth called a neuromyth, because their existence has not been confirmed by any reliable neuroscience research[261].

Nevertheless, it is also said that apart from learning styles, TEL should take into account other (not a neuromyth) features of the learner's personality, e.g. level of timidity, anxiety, self-reliance and thoughtfulness[262]. Otherwise, with the lack of personalization, TEL can be extremely ineffective. How can TEL be personalized?

Vahdat, Oneto, Anguita, Funk and Rauterberg[263] notice that the personalization of TEL should be based on professional Learning Analytics (LA). LA consist in "measuring, collecting and analyzing data about learners and their contexts and allow exploring the behaviour of people while learning"[264]. It is worth underlining that LA is currently one of the fastest developing do-

258. Ibidem, p. 24.
259. M.A. Khenissi, F. Essalmi, M. Jemni, Kinshuk, S. Graf & N.-S. Chen, Relationship between learning styles and genres of games. *Computers & Education, **101***, pp. 3, 7-9 (2016).
260. M. Rani, R. Nayak & O.P. Vyas, op. cit., pp. 42-47.
261. P.A. Howard-Jones, Neuroscience and education: myths and messages. *Nature Reviews Neuroscience, **15***, pp. 817–819 (2014); P.M. Newton, The learning styles myth is thriving in higher education. *Frontiers in Psychology, **6***, p. 2 (2015); P.M. Newton & M. Miah, Evidence-based higher education – is the learning styles "myth" important? *Frontiers in Psychology, **8***, pp. 6-8 (2017).
262. J. Sandars, Technology-enhanced learning. *Education for Primary Care, **23***, p. 137 (2012).
263. M. Vahdat, L. Oneto, D. Anguita, M. Funk & M. Rauterberg, Can machine learning explain human learning? *Neurocomputing, **192***, p. 14 (2016).
264. Ibidem.

mains of TEL[265] that combines scientific fields such as statistics, machine learning, cognitive science and pedagogy[266]. Using LA in TEL is above all supposed to make it possible to synchronize learning with the process of diagnosing students' preferences and capabilities, at the same time eliminating the problem of materials that are unadjusted to pupils, both in terms of its content and form[267]. LA are to be conducted simultaneously with respect to learning (they are to be completed in real time), and their results (reflecting the actual behaviour of the learner) are to determine the actual dynamics of the course of TEL[268].

The sense of LA in TEL is confirmed by the results of a lot of research. For example, studies by Tabuenca, Kalz, Drachsler and Specht[269] show that even a simple analysis of the time that a given person devotes to learning in a given context/space, and modifying the course of TEL based on this data, can significantly increase the effects achieved by them and equip them with high competencies in the area of self-regulated learning. Experiments by Minovic, Milovanovic, Sosevic and Gonzalez[270], as well as Munoz-Merino, Ruiperez-Valiente, Alario-Hoyos, Perez-Sanagustin and Kloos[271] show, on the other hand, that visualizing the progress in TEL in real time makes it possible to effectively and simultaneously correct the level of difficulty of the content discussed in a given situation, but also its form, according to the actual dynamics of pupils' cognitive abilities.

In LA, more and more stress is currently placed on the self-analysis of one's own process of learning. It is assumed that it is students themselves who can conduct the most effective process of TEL personalization[272]. Through the analysis of virtualized data originating from tools conducting LA, it is them

265. M. Minovic, M. Milovanovic, U. Sosevic & M.A.C. Gonzalez, Visualisation of student learning model in serious games. *Computers in Human Behavior, **47***, p. 99 (2015).
266. M. Vahdat, L. Oneto, D. Anguita, M. Funk & M. Rauterberg, op. cit., p. 14.
267. J. Konert, K. Richter, F. Mehm, S. Gobel, R. Bruder & R. Steinmetz, PEDALE – A peer education diagnostic and learning environment. *Journal of Educational Technology & Society, **15***, p. 27 (2012).
268. M. Minovic, M. Milovanovic, U. Sosevic & M.A.C. Gonzalez, op. cit., pp. 98, 106.
269. B. Tabuenca, M. Kalz, H. Drachsler & M. Specht, Time will tell: the role of mobile learning analytics in self-regulated learning. *Computers & Education, **89***, p. 69 (2015).
270. M. Minovic, M. Milovanovic, U. Sosevic & M.A.C. Gonzalez, op. cit., p. 106.
271. P.J. Munoz-Merino, J.A. Ruiperez-Valiente, C. Alario-Hoyos, M. Perez-Sanagustin & C.D. Kloos, op. cit., p. 117.
272. S. Kelle, A. Henka & G. Zimmermann, A Persona-based extension for massive open online courses in accessible design. *Procedia Manufacturing, **3***, pp. 3666-3667 (2015).

who would thus have to (on their own or with the teacher taking part) take decisions on how to correct TEL. Pupils would thus create TEL oscillation axes.

It seems, however, that rather neither pupils or teachers are actually interested in such a form of TEL personalization. Why is that? It can be explained by referring oneself to research results on the use of Web 2.0 in TEL.

As noted by Arh, Blazic and Dimovski[273], "when talking about TEL the impact of Web 2.0 technologies should not be overlooked. These Web 2.0 technologies are changing the way people share their knowledge, perspectives, opinions, thoughts and experiences across the web. Web 2.0 tools, such as instant-messaging systems, blogs, RSS, social bookmarking, VideoWiki, Doodle, podcasts and picture-sharing sites are becoming more and more popular. Web 2.0 is involved in various knowledge-management processes, including knowledge creation and thus contributes to the sustainability of competitive advantage through its interaction with other resources". Therefore, as observed by Hao and Lee[274], Web 2.0 provides an opportunity to learn creatively and in a pleasant way, and moreover – as underlined by De Wever, Hamalainen, Voet and Gielen[275] – in an environment that simulates real tasks, i.e. ones that make it possible to apply the knowledge they master in a practical way out of school. What is more, as research by Mavropalias and Brady[276] indicates, Web 2.0 is also so plastic a technology that it gives people with different learning styles an opportunity to learn effectively – it is a space that is fully open to (self)personalization. Freishtat and Sandlin[277] describe the Web 2.0 potential as understood above using the example of Facebook (FB). They claim that FB "has the potential to engage learners as creators of knowledge and as active participants in the learning process. In some ways, components of a critical transformational learning that seeks to redefine transformation

273. T. Arh, B.J. Blazic & V. Dimovski, op. cit., p. 371.
274. Y. Hao & K.S. Lee, Teachers' concern about integrating Web 2.0 technologies and its relationship with teacher characteristics. *Computers in Human Behavior, **48***, p. 1 (2015).
275. B. De Wever, R. Hamalainen, M. Voet & M. Gielen, A wiki task for first-year university students: the effect of scripting students' collaboration. *The Internet and Higher Education, **25***, p. 37 (2015).
276. K. Mavropalias & E. Brady, Social bits: personality and learning style profiling via the social web. In: A. Power & G. Kirwan (Eds.), *Cyberpsychology and new media: a thematic reader* (pp. 221-227). London – New York: Psychology Press (2014).
277. R.L. Freishtat & J.A. Sandlin, Facebook as public pedagogy: a critical examination of learning, community, and consumption. In: T.T. Kidd & J. Keengwe (Eds.), *Adult learning in the digital age: perspectives on online technologies and outcomes* (pp. 150-151). Hershey – New York: Information Science Reference (2009).

as something that involves both individual and social change and that takes seriously the social contexts within which learning takes place, can operate in FB and engage learners to build new, more democratic cultural realities. The collaborative, productive nature of FB and its usefulness as a platform for forming networks and sharing critical information on race, class, gender, and a wide variety of social-justice oriented social movements, hold possibilities for critical learning [...]. While FB users can create their own content through blogging or entering information on their walls, FB seems especially useful as a space that allows users to quickly and easily disseminate information that was produced or created elsewhere [...]. With FB, then, learners are able to share information quickly and easily with large numbers of people, making collaboration across time and space easy [...]. The ways people choose to learn and engage with knowledge is woven into a fluid process of change".

It would then seem that, as also observed by Jenkins, Browne, Walker and Hewitt[278], pupils should be willing to learn through Web 2.0 – thanks to this technology, they can run the (self)personalization of TEL, i.e. adjust the course of the process of learning to their own needs, abilities, preferences etc. However, it is not the way it is. A meta-analytical study conducted by Manca and Ranieri[279] shows that results of numerous studies unambiguously stress a general unwillingness of contemporary pupils to add Web 2.0 to school activities. They treat portals like FB as spaces separate from school and they do not have the faintest idea about how they can be used in the process of learning.

A similar dislike for using Web 2.0 in TEL can be noticed among teachers. On the one hand, as shown by research results by Hao and Lee[280], educators are simply afraid of the educational application of Web 2.0. In particular, this refers to young female teachers who are inexperienced in using TEL[281]. On the other hand, as demonstrated by the analyses by Roldan-Alvarez, Martin, Garcia-Herranz and Haya[282], most contemporary teachers do not have sufficient competences to use Web 2.0 in their educational practice effectively and ingeniously. This is why, to feel in control and protect their own absolute

278. M. Jenkins, T. Browne, R. Walker & R. Hewitt, op. cit., p. 462.

279. S. Manca & M. Ranieri, Is it a tool suitable for learning? A critical review of the literature on Facebook as a technology-enhanced learning environment. *Journal of Computer Assisted Learning, **29***, pp. 493-496 (2013).

280. Y. Hao & K.S. Lee, Teachers' concern... op. cit., p. 2.

281. Ibidem, p. 5.

282. D. Roldan-Alvarez, E. Martin, M. Garcia-Herranz & P.A. Haya, Mind the gap: impact on learnability of user interface design of authoring tools for teachers. *International Journal of Human-Computer Studies, 94*, pp. 18-19 (2016).

authority, they introduce the prohibition of Web 2.0 tools (such as FB) in the classroom, using at this point the term coined by Lally, Sharples, Tracy, Bertram and Masters[283]. And even if this prohibition is not legalized, they are completely unable to use the potential the Web 2.0 technology provides in the context of TEL personalization (teachers only transfer traditional forms of work to the Net[284]). In this context, Schwarz and Caduri[285] quote a very clear example: "Ilana's story is about using FB to enhance tradition. [...] for her, FB is a platform to present content, to direct questions to the group or to individual students, assess students' comments, diagnose misconceptions and provide further resources for learning. Her role is that of a content provider. For her, FB is a place, a virtual classroom, in which she is the expert. She controls the distribution of sources and their use through FB. She controls the instructional process, delivers the content to the entire class and tends to emphasize factual knowledge. The pedagogical model that guides Ilana's actions consists of transmission of information and less about knowledge building or collaborative work. Her motivation to use FB derives from her need to communicate with many students from different schools at the same time. Ilana understands the potential that FB holds as a geographical means: FB functions as a gathering place which allows her to do whatever she routinely does in her classroom, but with several classes and at the same time".

The student's self-analysis as far as one's process of learning goes as underlined above, and so much desired in TEL, directed at independent correction of TEL, thus geared towards the most effective form of TEL personalization, continues to seem difficult to implement, to say the least.

1.3.4. The need for research in cognitive neuroscience and psychophysiology

Noticed in the recent years, the exceptional interest in research into the human brain, linked to neuroscientific trends such as cognitive neuroscience and

283. V. Lally, M. Sharples, F. Tracy, N. Bertram & S. Masters, Researching the ethical dimensions of mobile, ubiquitous and immersive technology enhanced learning (MUITEL): a thematic review and dialogue. *Interactive Learning Environments, **20***, pp. 219-220 (2012).
284. I. Dror, P. Schmidt & L. O'Connor, A cognitive perspective on technology enhanced learning in medical training: great opportunities, pitfalls and challenges. *Medical Teacher, **33***, pp. 291-292 (2011).
285. B. Schwarz & G. Caduri, Novelties in the use of social networks by leading teachers in their classes. *Computers & Education, **102***, p. 48 (2016).

(though to a lesser extent) cognitive neuropsychology[286], leads to the more and more frequent discussion on the influence of ICT on the human brain[287]. Unfortunately, in spite of neuroscience being in fashion, this influence is not studied intensively or reliably. Most often in this context, the rather popular and journalistic understanding of the relation between new technologies and neuronal correlates of cognitive processes is applied, and thus TEL is unquestioningly considered to be beneficial for the human brain[288]. TEL promoters sometimes even start to believe in "a technopositivist ideology" where all ICT tools are perceived as spotless stimulants for the positive development of the human brain[289].

However, as observed by Pozdniakov and Posov[290], sometimes other yet equally journalistic reports show ICT tools as unambiguously detrimental to the human brain and doing the thinking for people. What is true then? According to Sandars[291], in order to design TEL well it is necessary to have knowledge on the nature of the process of learning that is very consolidated and – above all – based on the latest results of the best research. Dror, Schmidt and O'Connor[292] add that TEL has to be based on how the human brain works (from the perspective of cognitive processes), i.e. on cognitive neuroscience[293]. What is more, according to those researchers TEL also has to be "brain friendly"[294]. Thus, even though there is a need to conduct cognitive neuroscience research in the context of TEL, there are still very few reliable results of research devoted to this issue. In this paragraph, the most important and most recent of the few will be discussed. It may let us arrive at a reply to the question posed about the actual relation between ICT and the human brain.

286. M.W. Eysenck & M.T. Keane, *op. cit.*, pp. 2-23.
287. M. Klichowski & C. Patricio, op. cit., pp. 225-229.
288. H. Al-Khatib, Technology enhanced learning: virtual realities; concrete results – case study on the impact of TEL on learning. *European Journal of Open, Distance and E-Learning, **1***, p. 2 (2011).
289. I. Kinchin, Avoiding technology-enhanced non-learning. *British Journal of Educational Technology, **43***, p. E43 (2012); J. Rial, Technology-enhanced learning. *Education for Primary Care, **23***, p. 368 (2012).
290. S. Pozdniakov & I. Posov, Domain specific language approach to technology-enhanced learning. *Electronic Journal of Mathematics & Technology, **8***, p. 149 (2014).
291. J. Sandars, The challenge of cost-effective technology-enhanced learning for medical education. *Education for Primary Care, **22***, p. 67 (2011).
292. I. Dror, P. Schmidt & L. O'Connor, op. cit., p. 291.
293. M.W. Eysenck & M.T. Keane, *op. cit.*, pp. 2-23.
294. I. Dror, P. Schmidt & L. O'Connor, op. cit., p. 291.

One of the most interesting studies in this respect was carried out by Kretzschmar, Pleimling, Hosemann, Fussel, Bornkessel-Schlesewsky and Schlesewsky[295]. They examined the differences in reading a text displayed on various devices. These were: a paper page, an e-reader and a tablet computer. Thirty-six younger adults (mean age 25.7) and twenty-one older adults (mean age 66.8) participated in the study. Using the EEG and questionnaire methods, the researchers discovered that irrespective of age the effectiveness of reading a text is not determined by the type of the device it is displayed on. As shown in Figure 1.19, the subjects declared that reading was most pleasurable for them when they were reading the text from a paper page, and that it seems to provide the best readability for them (interestingly, a tablet computer was evaluated in a similar way by older adults), yet EEG data unambiguously show that a text displayed on different devices is processed in the same way by the human brain.

Research by Small, Moody, Siddarth and Bookheimer[296] shows, however, that the situation is slightly different when it comes to reading a hypertext implemented on the Internet. When reading, people who read a lot of different materials online start to activate not only those areas in their brains that are characteristic for this process, but also those that are responsible for decision making (as hypertexts are not linear, but lead the reader and are open to constant changes and give an opportunity to click on new threads). These results are interpreted as proof that intense technological experiences change the way the human brain functions (and may even change the way it is organised)[297].

What is more, an experiment by Di Giacomo, Cofini, Di Mascio, Rosita, Fiorenzi, Gennari and Vittorini[298] shows that learning to read based on ICT may be more effective than traditional methods. Those researchers proved that using their original Terence program for six months by children positively influences their reading abilities (Terence improved their psychological per-

295. F. Kretzschmar, D. Pleimling, J. Hosemann, S. Fussel, I. Bornkessel-Schlesewsky & M. Schlesewsky, Subjective impressions do not mirror online reading effort: concurrent EEG-eyetracking evidence from the reading of books and digital media. *PLoS ONE, **8***, pp. 2-10 (2013).

296. G.W. Small, T.D. Moody, P. Siddarth & S.Y. Bookheimer, Your brain on Google: patterns of cerebral activation during internet searching. *The American Journal of Geriatric Psychiatry, **17***, pp. 116-126 (2009).

297. L. Hadlington, Cognitive factors in online behaviour. In: A. Attrill (Ed.), *Cyberpsychology* (pp. 256-257). New York: Oxford University Press (2015).

298. D. Di Giacomo, V. Cofini, T. Di Mascio, C.M. Rosita, D. Fiorenzi, R. Gennari & P. Vittorini, The silent reading supported by adaptive learning technology: influence in the children outcomes. *Computers in Human Behavior, **55***, p. 1129 (2016).

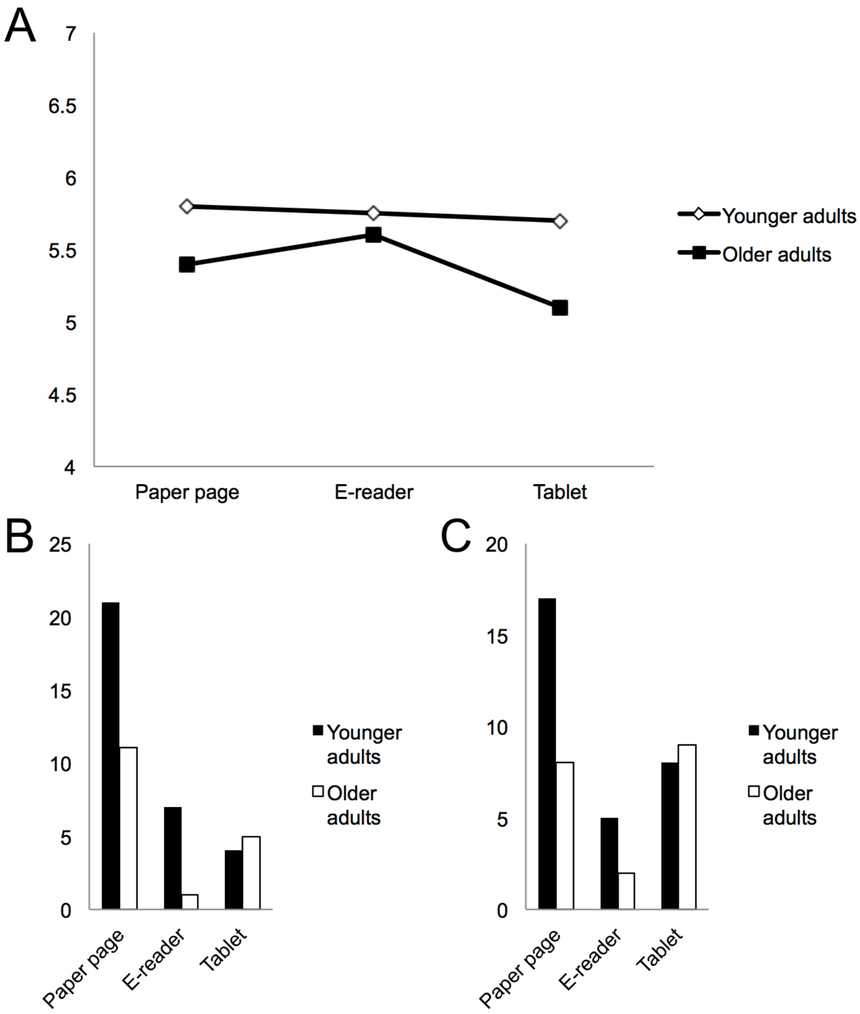


Figure 1.19. Results of an experiment on processing a text displayed on different devices by the human brain. **(A)** Mean voltage density measures per page of text displayed on different devices. **(B)** Declared level of pleasure while reading a text displayed on different devices. **(C)** Evaluation of the devices with the best readability. Source: F. Kretzschmar, D. Pleimling, J. Hosemann, S. Fussel, I. Bornkessel-Schlesewsky & M. Schlesewsky, Subjective impressions do not mirror online reading effort: concurrent EEG-eyetracking evidence from the reading of books and digital media. *PLoS ONE*, ***8***, pp. 6, 8 (2013). Under the terms of the Creative Commons Attribution License.

formance, e.g. speed and reading time)[299]. This program "aims to carry out a software to improve the reading comprehension of its main learners. The program develops an Adaptive Learning System (ALS): is a computer-based

299. Ibidem, pp. 1128-1129.

and/or online educational system that modifies the presentation of material in response to subject performance"[300].

Things are different, however, in the context of learning to write, when ICT tools deprive children of the incredibly important corporal experience in this process. Mangen and Velay[301] explain this as follows: "The switch from pen and paper to mouse, keyboard and screen entails major differences in the haptics of writing, at several distinct but intersecting levels. Handwriting is by essence a unimanual activity, whereas typewriting is bimanual. Typically, handwriting is also a slower process than typewriting. Moreover, the visual attention of the writer is strongly concentrated during handwriting; the attentional focus of the writer is dedicated to the tip of the pen, while during typewriting the visual attention is detached from the haptic input, namely the process of hitting the keys. Hence, typewriting is divided into two distinct, and spatiotemporally separated, spaces: the motor space (e.g., the keyboard), and the visual space (e.g., the screen). Another major difference pertains to the production of each character during the two writing modes. In handwriting, the writer has to graphomotorically form each letter – i.e., produce a graphic shape resembling as much as possible the standard shape of the specific letter. In typewriting, obviously, there is no graphomotor component involved; the letters are readymades and the task of the writer is to spatially locate the specific letters on the keyboard [...]. A large body of research in neuroscience, biopsychology and evolutionary biology demonstrates that our use of hands for purposive manipulation of tools plays a constitutive role in learning and cognitive development, and may even be a significant building block in language development. Furthermore, brain imaging studies (using fMRI, i.e., functional Magnetic Resonance Imaging) show that the specific hand movements involved in handwriting support the visual recognition of letters".

Moreover, Gindrat, Chytiris, Balerna, Rouiller and Ghosh[302] discovered that intense screen tapping itself is strongly correlated with negative changes in the human brain. Using the EEG method, those researchers compared the brain activity of right-handed touchscreen phone users (26 people) and nonusers (11 people using phones with a traditional keyboard). It turned out

300. Ibidem, p. 1126.
301. A. Mangen & J.-L. Velay, Digitizing literacy: reflections on the haptics of writing. In: M.H. Zadeh (Ed.), *Advances in haptics* (pp. 385-386). Rijeka – Shanghai: InTech Open Access Publisher (2010).
302. A.-D. Gindrat, M. Chytiris, M. Balerna, E.M. Rouiller & A. Ghosh, Use-dependent cortical processing from fingertips in touchscreen phone users. *Current Biology,* ***25***, pp. 109-113 (2015).

that the intense use of a touchscreen phone reorganised the representation of right-hand fingers in the somatosensory cortex. As shown by previous research conducted by Berolo, Wells and Amick[303], this type of reorganisation in the human brain is significantly correlated with the development of chronic pain. For this reason, despite the lack of any deficits in the physical state of the hand, right-handed people who permanently use ICT so frequently suffer from pain in their right-hand fingers, as well as in the right shoulder or neck (and, by analogy, the same probably applies to left-handed people, although their situation is often contextually complicated[304]).

A different study that also used EEG, as well as transcranial magnetic stimulation (TMS), revealed that smartphone users ($N = 17$), as compared to nonusers ($N = 38$), achieve much worse results in an information processing task. Furthermore, the team including Hadar, Eliraz, Lazarovits, Alyagon and Zangen[305] who conducted the research carried out an additional 3-month experiment where half of the previously studied nonusers took part. They received smartphones and were trained in how to use them. Shocking as it may seem, it turned out that even such a short period of time of using a smartphone was enough for the effectiveness of information processing in their brains to decrease significantly (it did not change in the control group, i.e. the other half of nonusers).

Loh and Kanai's[306] research results seem even more shocking. They used the Media Multitasking Questionnaire, aimed at diagnosing the Media Multitasking Index (MMI), i.e. the level of intensity of using ICT tools (both in the context of time, type of activity and number of tools[307]) and the fMRI method. They chose the anterior cingulate cortex (ACC), one of the most important

303. S. Berolo, R.P. Wells & B.C. Amick, Musculoskeletal symptoms among mobile handheld device users and their relationship to device use: a preliminary study in a Canadian university population. *Applied Ergonomics, **42***, pp. 371-378 (2011).
304. G. Kroliczak, Praxis in left-handers. *Culture and Education, **99***, pp. 5-31 (2013); G. Kroliczak, B.J. Piper & S.H. Frey, Atypical lateralization of language predicts cerebral asymmetries in parietal gesture representations. *Neuropsychologia, **49***, pp. 1698-1702 (2011); G. Kroliczak, B.J. Piper & S.H. Frey, Specialization of the left supramarginal gyrus for hand-independent praxis representation is not related to hand dominance. *Neuropsychologia, **93***, pp. 501-512 (2016).
305. A.A. Hadar, D. Eliraz, A. Lazarovits, U. Alyagon & A. Zangen, Using longitudinal exposure to causally link smartphone usage to changes in behavior, cognition and right prefrontal neural activity. *Brain Stimulation, **8***, pp. 318-318 (2015).
306. K.K. Loh & R. Kanai, Higher media multi-tasking activity is associated with smaller gray-matter density in the anterior cingulate cortex. *PLoS ONE, **9***, pp. 2-5 (2014).
307. E. Ophir, C. Nass & A.D. Wagner, Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences of the United States of America, **106***, p. 15586 (2009).

areas for information processing in the human brain, as their regions of interest (ROI). As shown in Figure 1.20, Loh and Kanai discovered that the higher the MMI scores in a given person, the smaller their gray matter density in

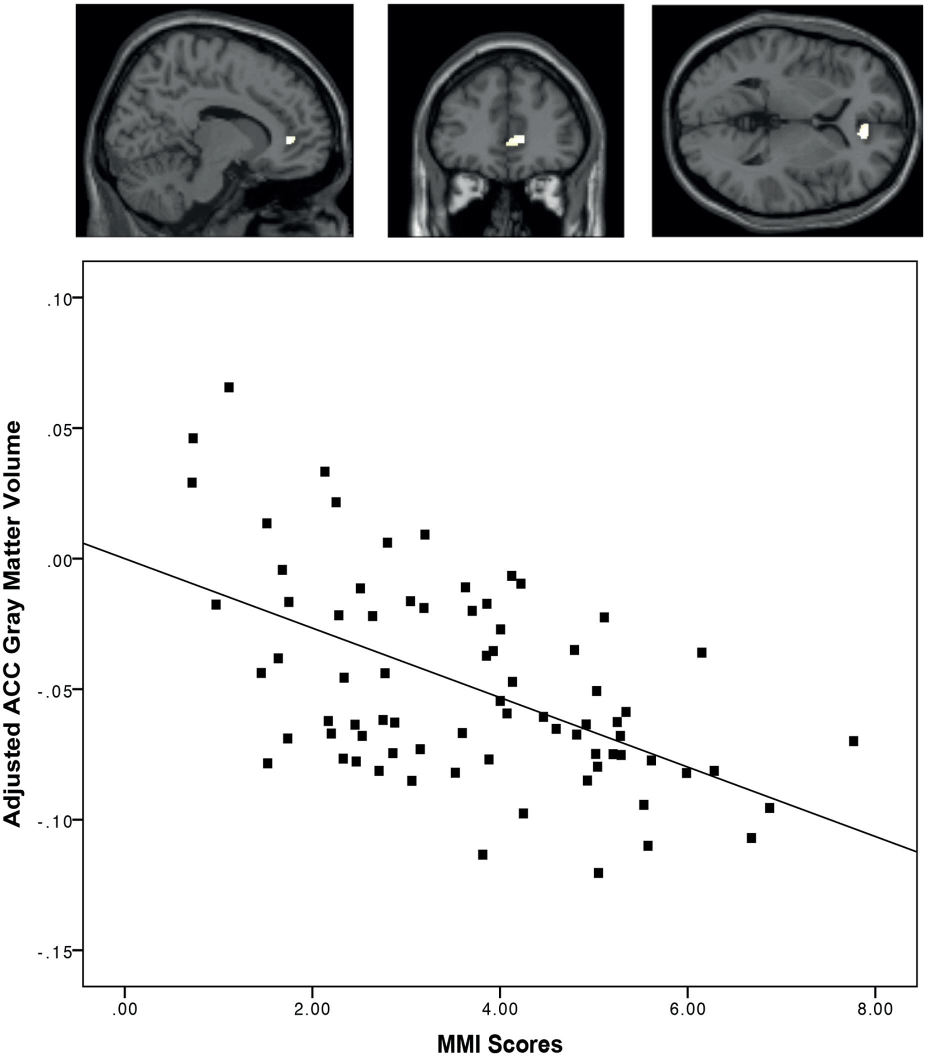


Figure 1.20. Results of an experiment on the correlation between the Media Multitasking Index (MMI) scores and the gray matter volume in the anterior cingulate cortex (ACC). MMI scores show the level of intensity of using ICT tools. ACC is one of the most important areas in the human brain as far as information processing is concerned, and its decreased gray matter density may lead to decreased cognitive control performance, as well as cause negative socio-emotional outcomes. Source: K.K. Loh & R. Kanai, Higher media multi-tasking activity is associated with smaller gray-matter density in the anterior cingulate cortex. *PLoS ONE*, ***9***, p. 4 (2014). Under the terms of the Creative Commons Attribution License.

ACC. Those researchers add that it means that the intense use ICT tools negatively changes the cerebral cortex, and these changes may decrease cognitive control performance, as well as lead to negative socio-emotional outcomes[308].

The above-mentioned results of the latest research into ICT, conducted within cognitive neuroscience paradigms, show that TEL does not necessarily have to bring positive effects. A very intense use of ICT tools may lead to negative changes in the brain, affecting not only the human's cognitive functioning, but also their well-being, social relations and health. Of course each of these results show only a certain fragment of the large spectrum of possible TEL effects. Theoreticians are of the opinion that deduction in analysing cognitive neuroscience should thus be carried out by means of the convergence method, i.e. combining large quantities of data gathered through various research procedures (EEG, TMS, fMRI etc.). Unfortunately, as shown earlier, there is still very little data of this type in the context of TEL. It is also worth complementing research procedures from within cognitive neuroscience with those coming from other fields, psychophysiology in particular. Several studies have shown that taking measurements of the heart rate (HR), heart rate variability (HRV), blood pressure[309], electrodermal activity (EDA), e.g. skin conductance level (SCL) and skin conductance response (SCR) [310] may be useful in this respect, among others. It is also desirable that data measuring the activity of the brain be combined with data coming from behavioural experiments[311].

Conclusions

In this chapter it was established that TEL is a theory of learning with the use of (any type of) technology that is applied in order to enrich the cooperation and enable access to social information resources, and at the same time stimulate student's own, individual and creative activity that makes it possible to assign

308. K.K. Loh & R. Kanai, op. cit., p. 6.
309. B. Cowley, M. Fantato, C. Jennett, M. Ruskov & N. Ravaja, Learning when serious: psychophysiological evaluation of a technology-enhanced learning game. *Journal of Educational Technology & Society*, ***171***, p. 4 (2014).
310. M. Slater, A. Antley, A. Davison, D. Swapp, C. Guger, C. Barker, N. Pistrang & M.V. Sanchez-Vives, A virtual reprise of the Stanley Milgram obedience experiments. *PLoS ONE*, ***1***, p. 3 (2006).
311. L. Schilbach, A.M. Wohlschlaeger, N.C. Kraemer, A. Newen, N.J. Shah, G.R. Fink & K. Vogeley, Being with virtual others: neural correlates of social interaction. *Neuropsychologia*, ***44***, pp. 720-722 (2006).

individualized meanings to the elements of reality that they get to know. The latest phase of TEL development is smart learning, an element of smart education. The latter is, on the other hand, a part of the concept of smart cities, i.e. technologically-developed cities. Thus, TEL becomes the first pillar of the idea of learning in CyberParks. The other will be described in the following chapter.

Furthermore, this chapter shows that TEL can be evaluated in different ways. There are research results that both glorify and completely deprecate this vision of learning. In order to evaluate TEL in a reliable manner, it is necessary to conduct research within cognitive neuroscience paradigms. Even though the results of such research are only authorized through convergence, they show the real (neuronal or behavioral) effects of using ICT in the process of learning.

When summarizing this chapter, it is also worth paying attention to yet one more issue. Lakkala and Ilomaki[312] notice that we currently experience a certain global problem in the context of TEL: teachers are not prepared to use the full potential of TEL. What is more, as stated by Cooner[313], TEL is most often introduced at schools not as a strategy for enriching the learning process, but as a remedy for deficiencies related to high costs of education and its accessibility for pupils, among others. Thus, as observed by Scanlon[314], when TEL is applied, "the gap between potential and actual practice" is commonly noticed. In addition, the introduction of TEL is accompanied by focus on technologies, and not on teachers' competences, pivotal for the effectiveness of TEL[315]. The crucial role of the teacher in TEL is thus globally ignored, which contributes to the radical devaluation of TEL[316].

312. M. Lakkala & L. Ilomaki, A case study of developing ICT-supported pedagogy through a collegial practice transfer proces. *Computers & Education,* ***90***, pp. 1-2 (2015).

313. T.S. Cooner, Creating opportunities for students in large cohorts to reflect in and on practice: lessons learnt from a formative evaluation of students' experiences of a technology-enhanced blended learning design. *British Journal of Educational Technology,* ***41***, p. 273 (2010).

314. E. Scanlon, Technology enhanced learning in science: interactions, affordances and design based research. *Journal of Interactive Media in Education,* ***2***, p. 13 (2010).

315. N. Belo, S. McKenney, J. Voogt & B. Bradley, Teacher knowledge for using technology to foster early literacy: a literature review. *Computers in Human Behavior,* ***60***, pp. 372-373 (2016); A. Pulman, K. Galvin & M. Hutchings, Empathy and dignity through technology: using lifeworld-led multimedia to enhance learning about the head, heart and hand. *Electronic Journal of e-Learning,* ***10***, p. 358 (2012).

316. A. Raes & T. Schellens, The effects of teacher-led class interventions during technology-enhanced science inquiry on students' knowledge integration and basic need satisfaction. *Computers & Education,* ***92-93***, p. 138 (2016).

Kirkwood and Price[317] notice that when TEL was developing in the 1970s, most theoreticians of education claimed that no technology can enrich the process of learning. Today, we know that it is possible. However, as shown in this chapter, the use of ICT in education requires intuition and knowledge. This is because TEL can both stimulate and disturb human cognitive processes. A quote from Graham and Zengin's[318] can serve as a good summary (and a word of warning) of the considerations in this chapter: "Learning can be hard. Not learning can be even harder. This is true for both learners and the organizations that are responsible for their training. It is clear that technology, at some level, has now become a reality in the workplace and in education. However, as practitioners remind us, it is not enough to have a computer budget and a training materials syllabus; groundwork must be laid for learning to take place [...]. All decisions must be made with the following caveat: When technology is used improperly, for the wrong reasons, or without the proper resources in place, it's likely to be slow, expensive, and inefficient".

317. A. Kirkwood & L. Price, The influence upon design of differing conceptions of teaching and learning with technology. In: A.D. Olofsson & J.O. Lindberg (Eds.), *Informed design of educational technologies in higher education: enhanced learning and teaching* (p. 2). Hershey: Information Science Reference (2012).
318. E.R. Graham & S. Zengin, Issues to consider for using e-learning effectively: smart learning in law enforcement contexts. *Journal of Graduate School of Social Sciences,* ***15***, p. 2 (2011).

CHAPTER 2

Outdoor learning

Introduction

It is estimated that by 2050 the population of city dwellers will have risen (as compared to the current number) by almost 65%[319]. It thus seems that the upcoming decades will be accompanied by the intensification of sedentary lifestyle (i.e. life without real physical activity)[320], which has already reached a catastrophic scale. McCurdy, Winterbottom, Mehta and Roberts[321] claim that the chronic lack of movement which has been on the increase among city dwellers will lead the next generation to a situation where children will be doomed to a life shorter than their parents' (which has never happened in the human history so far). What is more, numerous research results conducted by cognitive scientists, exercise physiologists, educational psychologists, neurobiologists and physical educators show that low physical activity (permanently) destructs the human brain, thus next generations will not only live shorter and get ill more frequently, but their effectiveness of learning will also decrease[322].

319. L. Gong, B. Mao, Y. Qi & C. Xu, A satisfaction analysis of the infrastructure of country parks in Beijing. *Urban Forestry & Urban Greening, **14***, p. 480 (2015).
320. L.E. McCurdy, K.E. Winterbottom, S.S. Mehta & J.R. Roberts, Using nature and outdoor activity to improve children's health. *Current Problems in Pediatric and Adolescent Health Care, **40***, p. 103 (2010).
321. Ibidem, p. 102.
322. E. Jensen, *Brain-based learning. The new paradigm of teaching*. Thousand Oaks: Corwin Press, pp. 37-41 (2008).

The above-mentioned trends in the changes of the human life rhythm have also led to the creation of a nature-deficit disorder[323]. Discovered by Louv[324], this phenomenon shows that because most people have "little contact and experience in nature" today, they are affected by "costs of alienation from nature", e.g. "diminished use of the senses, attention difficulties, and higher rates of physical and emotional illnesses". Likewise, more and more researchers claim that for the man to be (physically and mentally) healthy and cognitively effective, they have to return to the broadly understood nature – to frequent and natural (typical for non-urban eras) movement outside, in green space[325]. This claim is based on an interdisciplinary methodology called bioinspiration (or biomimicry) where nature's genius is a source of not only inspiration, but also of behaviour and life patterns[326].

It has to be added that the nature-deficit disorder not always has to be a consequence of a contemporary man's lifestyle uninspired by nature. In the city, it is more and more frequent to come across the phenomenon called "green space reduction"; there are fewer and fewer parks or green spots with trees, bushes, flowers etc[327]. What is more, as indicated by Chin-Shyang and Mei-Ju[328], most of those already scarce urban green spaces that are created are designed arbitrarily, i.e. in a way that does not take the needs and expectations of city dwellers into account. Urban green spaces are generally treated simply as obligatory city elements, mainly aimed at fulfilling certain aesthetic and formal standards. In the city, the contact with nature has thus simply been hindered, and sometimes actually impossible. However, as manifested by

323. L.G. D'Amato & M.E. Krasny, Outdoor adventure education: applying transformative learning theory to understanding instrumental learning and personal growth in environmental education. *Journal of Environmental Education, **42***, p. 238 (2011).
324. R. Louv, *Last child in the woods: saving our children from nature-deficit disorder*. Chapel Hill, NC: Algonquin Books, p. 36 (2008).
325. R. Black, Delivering formal outdoor learning in protected areas: a case study of Scottish Natural Heritage National Nature Reserves. *International Research in Geographical & Environmental Education, **22***, p. 4 (2013).
326. M. Topaz, Bioinspiration education at zoological institutions: an optimistic approach for innovation leading to biodiversity conservation. *International Zoo Yearbook, **50***, p. 112 (2016).
327. R. Onder & A.A. Kocaeren, Investigating the nature project as a permanent, widespread and economic solution to environmental problems. *Procedia – Social and Behavioral Sciences, **182***, p. 155 (2015).
328. S. Chin-Shyang & C. Mei-Ju, Whose aesthetics world? Exploration of aesthetics cultivation from the children's outdoor playground experiential value perspective. *International Journal of Organizational Innovation, **8***, p. 160 (2015).

Dillon[329], each city dweller "should have fair access to a good quality natural environment". Interestingly, Dillon[330] claims that education is a panacea for this problem. How should we understand that?

Topaz[331] underlines that bioinspiration education, i.e. education to a large extent based on active and interdisciplinary outdoor learning (OL), is one of the most important ways of tackling the deficit of movement and nature. It is assumed that education should be fully inspired by nature[332], and that not only indoor spaces, but also to at least the same extent outdoor spaces[333] should be taken into consideration when planning where it takes place. As observed by Tavares, Silva and Bettencourt, OL is thus becoming a certain type of a consensus that balances the need of institutional learning with the need to move around and be close to nature[334].

The legitimacy of the educational use of outdoor spaces is confirmed by numerous studies. It turns out, for example, that the more time a given person spends outdoors, the more physically active they are (for each hour of staying outdoors, there is an average of 27 minutes of more physical activity than in case of staying indoors)[335]. As underlined by Lyngas Eklund, Ruud and Grov[336], nature is an optimum space for physical activity. What is more, those who often learn outdoors are much healthier[337] and have much better social interactions[338]. Green outdoor spaces are also optimum for learning itself[339].

329. J. Dillon, Barriers and benefits to learning in natural environments: towards a reconceptualisation of the possibilities for change. *Cosmos, **8***, p. 153 (2013).
330. Ibidem, p. 154.
331. M. Topaz, op. cit., p. 113.
332. C. Nuttal & J. Millington, *Outdoor Classrooms: A Handbook for School Gardens*. London: Permanent Publications, p. 21 (2012).
333. J. Merewether, Young children's perspectives of outdoor learning spaces: what matters? *Australasian Journal of Early Childhood, **40***, p. 99 (2015).
334. A.C. Tavares, S. Silva & T. Bettencourt, Advantages of applying IBSE method: the coimbra inquire course case-study. *Procedia – Social and Behavioral Sciences, **191***, pp. 175-177 (2015).
335. L.E. McCurdy, K.E. Winterbottom, S.S. Mehta & J.R. Roberts, op. cit., pp. 107-108.
336. M. Lyngas Eklund, I. Ruud & E.K. Grov, The forest as a classroom: preparing for mental health practice. *BMC Nursing, **15***, p. 2 (2016).
337. S.V. Caldas, E.T. Broaddus & P.J. Winch, Measuring conflict management, emotional self-efficacy, and problem solving confidence in an evaluation of outdoor programs for inner-city youth in Baltimore, Maryland. *Evaluation and Program Planning, **57***, p. 64 (2016).
338. Y. Durmus & A.E. Yapicioglu, Kemaliye (Erzincan) ecology based nature education project in participants' eyes. *Procedia – Social and Behavioral Sciences, **197***, p. 1139 (2015).
339. E.M. Costel, Didactic options for the environmental education. *Procedia – Social and Behavioral Sciences, **180***, p. 1381 (2015).

This is because nature maintains the memory and attention on a level that is ideal for learning[340].

It is worth adding that even plain urban green spaces can be important nature meeting points for pupils from the city. In a study by Merewether[341], the behaviours of pupils from a city school during outdoor activities were observed for three months, which showed that such activities are sufficient for pupils to be able to learn through observing real phenomena, be physically active and improve interpersonal relations. Furthermore, Chin-Shyang and Mei-Ju[342] emphasize it that even in urban green spaces outdoor activities are incredibly attractive for pupils in the city, because they are particularly curious about the natural world (as compared to pupils in rural areas, for example).

OL is thus currently becoming more and more popular[343], or even trendy[344]. (An excellent exemplification of this trend is provided by Waite[345]. She notices that one of the classic papers devoted to OL written by Bonnett and Williams, titled *Environmental education and primary children's attitudes towards nature and the environment,* and published in 1998 in the *Cambridge Journal of Education*, is currently the most frequently quoted article coming from this journal). This concept is still mainly used in informal education[346]; however, policy makers and teacher education institutions[347], as well as teachers and

340. M. Cassarino & A. Setti, Environment as "brain training": a review of geographical and physical environmental influences on cognitive ageing. *Ageing Research Reviews, **23B***, pp. 167-182 (2015); A.L.E.V. Cassidy, W.A. Wright & W.B. Strean, The interplay of space, place and identity: transforming our learning experiences in an outdoor setting. *Collected Essays on Learning and Teaching, **8***, pp. 27-34 (2015); S. Caparos, L. Ahmed, A.J. Bremner, J.W. de Fockert, K.J. Linnell & J. Davidoff, Exposure to an urban environment alters the local bias of a remote culture. *Cognition, **122***, pp. 80-85 (2012).
341. J. Merewether, op. cit., pp. 101-104.
342. S. Chin-Shyang & C. Mei-Ju, op. cit., p. 166.
343. L.M. Gutman & I. Schoon, Preventive interventions for children and adolescents: a review of meta-analytic evidence. *European Psychologist, **20***, p. 235 (2015).
344. E. Howden, Outdoor experiential education: learning through the body. *New Directions for Adult and Continuing Education, **134**,* pp. 43-51 (2012).
345. S. Waite, "Knowing your place in the world": how place and culture support and obstruct educational aims. *Cambridge Journal of Education, **43***, p. 413 (2013).
346. H.T. Zimmerman & L.R. McClain, Family learning outdoors: Guided participation on a nature walk. *Journal of Research in Science Teaching, **53***, pp. 919-942 (2016).
347. B. Christie, S. Beames & P. Higgins, Context, culture and critical thinking: Scottish secondary school teachers' and pupils' experiences of outdoor learning. *British Educational Research Journal, **42***, p. 417 (2016).

pupils themselves[348], have been showing interest in it more and more often. The need to formally adapt OL[349] is mentioned more and more frequently.

What is OL then and how should we understand it? Has the educational potential of this concept been scientifically proven in a clear way? This chapter is an attempt at answering these questions. In the first paragraph, this concept's background, i.e. discussions on outdoor education (OE), will be presented. The next subchapter will discuss the definitions of OL. Finally, the last subchapter will present the results of the most recent research on OL. The chapter will end with an attempt at a short description of the most important issues related to OL, selected in line with the topic covered by this book.

2.1. Outdoor education

As intriguingly demonstrated by Whitbread[350], the beginnings of the OE idea can be found as early as in Aristotle, "who had a practice of strolling about the temple of the Lycian Apollo [...] as he taught". Indeed, as indicated by Tan and Atencio[351], among others, the concept refers to every type of outdoor experience that can be used for educational purposes. Cengelci[352] adds, however, that OE "includes a relationship between the natural environment and human, and requires experiential learning, using all senses, and focusing on interdisciplinary subjects".

Hoad, Deed and Lugg[353] observe in this context that OE differs from classroom-based education with at least five elements:

- Firstly, in OE, a much bigger stress is placed on making pupils' experiences natural, on making sure that their context of learning is not artificial (i.e. that it is not artificially created in the classroom).

348. M. Green, Transformational design literacies: children as active place-makers. *Children's Geographies, **12***, p. 199 (2014).
349. S. Waite, R. Passy, M. Gilchrist, A. Hunt & I. Blackwell, *Natural connections demonstration project, 2012–2016: final report*. Plymouth: Natural England Commissioned Reports (2016).
350. H. Whitbread, The water lily and the cyber cow, landscape as a platform for education for sustainability in the higher education sector. *Current Opinion in Environmental Sustainability, **16***, p. 23 (2015).
351. Y.S.M. Tan & M. Atencio, Unpacking a place-based approach – "What lies beyond?" Insights drawn from teachers' perceptions of outdoor education. *Teaching and Teacher Education, **56***, p. 25 (2016).
352. T. Cengelci, Social studies teachers' views on learning outside the classroom. *Educational Sciences: Theory and Practice, **13***, p. 1837 (2013).
353. C. Hoad, C. Deed & A. Lugg, The potential of humor as a trigger for emotional engagement in outdoor education. *Journal of Experiential Education, **36***, pp. 42-43 (2013).

– Secondly, through OE, pupils are supposed not only to leave the school building, but also their "outside comfort zone", i.e. they are supposed to learn also outside of the super-safe, sterile and hollow school environment that does not reflect the reality, shape perseverance or teach real risk assessment.
– Thirdly, restrictive school norms related to language and movement, among others, are radically transformed in OE for the sake of considerable spontaneity in pupils' (both communicative and physical) behaviour.
– Fourthly, in OE, teachers and pupils enter completely different roles than in indoor education. Instead of being just a leader, facilitator, and instructor, teachers start playing the role of, for example, a cook, medic, navigator, and carer. On the other hand, the pupil enters the role of a discoverer and expert who can reveal all their passions and interests, as well as diverse strategies of learning.
– Fifthly, and finally, with a plethora of venues and interactions, OE is supposed to encourage pupils to have a critical reflection on everyday lifestyles, as well as their own strong opinions, also on the methods, forms and sources of learning.

What is more, OE supplements traditional school interactions (interactions between learners, the learner and educator) with interactions between the learner and environment[354]. As a consequence, as stated by Smeds, Jeronen and Kurppa[355], OE includes both environmental education and education for sustainable development. OE is thus not only education outside the school building, but also education for the environment; it educates how to look after it and shapes the love of nature[356]. Meiboudi, Lahijanian, Shobeiri, Jozi and Azizinezhad[357] even come to claim that OE "is the most fundamental way to protect the environment". It is assumed, however, that in this context OE may

354. Ibidem, p. 41.
355. P. Smeds, E. Jeronen & S. Kurppa, Rural camp school eco learn – outdoor education in rural settings. *International Journal of Environmental and Science Education, **6***, p. 268 (2011).
356. R. Onder & A.A. Kocaeren, Analysis of science teacher candidates' environmental knowledge, environmental behavior and self-efficacy through a project called "Environment and energy with professional science education". *Procedia – Social and Behavioral Sciences, **186***, p. 106 (2015).
357. H. Meiboudi, A. Lahijanian, S.M. Shobeiri, S.A. Jozi & R. Azizinezhad, Creating an integrative assessment system for green schools in Iran. *Journal of Cleaner Production, **119***, p. 239 (2016).

take two forms: that of emancipatory OE, referring to shaping an identity that fights for environmental protection, and that of instrumental OE, linked to shaping an identity that simply looks after the environment[358].

OE is not about abandoning the school classroom and emancipating education from any buildings. Burriss and Burriss[359] state that "the outdoors becomes a natural extension of the indoor classroom". OE does not have to occur in any specific natural conditions, either. As defined by Jenkins[360], any parks or green spots, or simply normal school green spaces will be sufficient. What is more, the above-mentioned Burriss and Burriss[361] indicate that "the outdoor classroom may begin with a picnic table, a few benches, or a window sill or pole bird feeder". Obviously, the participants of the process of education would gain much bigger opportunities if these spaces were equipped with portable tables and chairs, as well as if they had access to running water, lighting, overhead shelter, seating, signage, trash receptacles and outdoor storage areas[362]. However, this is not indispensable for actual OE to occur, which has to be very firmly underlined at the end of this paragraph.

As a side note, it is worth mentioning an interesting form of introducing OE that was presented by Gustafson and van der Burgt[363]. They described a Swedish kindergarten whose building was replaced with a bus. The bus is a shelter from difficult weather conditions; it also contains a dining area and a toilet. Parents drop and pick up their children on the parking lot, and depending on the day, the kids learn in different places. This allows the children to reach various types of interesting natural spots where the entire process of education takes place.

To summarize this subchapter, OE assumes a partial transfer of the process of learning outdoors, away from an educational institution, towards places that are close to nature. These do not have to be forests, woods, or some mountainous areas. Very importantly for the considerations in this book, a park where various elements of education can be completed for some time, learning included, is sufficient. This is where the OL concept appears.

358. L.G. D'Amato & M.E. Krasny, op. cit., p. 237.
359. K. Burriss & L. Burriss, Outdoor play and learning: policy and practice. *International Journal of Education Policy and Leadership, **6***, p. 1 (2011).
360. M. Jenkins, Sustainability in schools: give young eco-warriors space to grow. *Taproot Journal, **23***, p. 40 (2014).
361. K. Burriss & L. Burriss, op. cit., p. 4.
362. Ibidem, pp. 4-5.
363. K. Gustafson & D. van der Burgt, "Being on the move": time-spatial organisation and mobility in a mobile preschool. *Journal of Transport Geography, **46***, pp. 201-209 (2015).

2.2. Outdoor learning concept

As noted by Quinn[364], the OL concept "sees nature as a space within which humans act". This researcher adds that OL is a concept where learning can be completed not only as an element of OE, but also "informally and incidentally as a byproduct of outdoor engagement, during such activities as environmental activism"[365]. OL thus refers both to formal and informal learning. What is more, as observed by Janiuk[366], OL does not have to take place exclusively close to nature. Its forms are, for example, all sorts of science festivals, picnics or research nights. As underlined by Thorburn and Allison[367], the essence here is a real, true context of learning. In OL, it is simply about going beyond school classroom or one's own house and learning through observation and participation in real life[368] that takes place both in the natural and artificial (man-made) environments[369]. It is assumed here that "the physical and cultural natural environments offer the learning framework"[370], which is sometimes referred to as place-based pedagogy. Assuming such a perspective, Christie, Beames and Higgins[371] conclude that, mostly generally speaking, OL "is regarded as pedagogy – a means to deliver the curriculum from across many disciplines in authentic contexts".

As previously underlined, it is the vicinity of nature, however, that forms a special value of OL in the contemporary world[372]. And it is in this form, as stressed by Black[373], i.e. learning in school grounds, parks, protected areas etc., that the OL concept has become to be more and more intensively introduced

364. J. Quinn, Theorising learning and nature: post-human possibilities and problems. *Gender & Education, **25***, p. 739 (2013).
365. Ibidem, p. 739.
366. R.M. Janiuk, Usefulness of out-of-school learning in science education. *Journal of Baltic Science Education, **12***, pp. 128-129 (2013).
367. M. Thorburn & P. Allison, Analysing attempts to support outdoor learning in Scottish schools. *Journal of Curriculum Studies, **45***, p. 420 (2013).
368. T. Cengelci, op. cit., p. 1838.
369. P. Smeds, E. Jeronen & S. Kurppa, Rural camp... op. cit., p. 271.
370. E. Moldovan & R.S. Enoiu, Study regarding the social-affective maturity degree through outdoor education activities. *Bulletin of the Transilvania University of Brasov, Series IX: Sciences of Human Kinetics, **7***, p. 28 (2014).
371. B. Christie, S. Beames & P. Higgins, op. cit., p. 418.
372. S. Waite, op. cit., p. 413; D. O'Reilly, Outdoor learning for general practitioners. *Education for Primary Care, **25***, pp. 57-58 (2014).
373. R. Black, op. cit., p. 6.

into formal education. As defined by Chin-Shyang and Mei-Ju[374], the outdoor is supposed to be a nature-based extension for student's indoor school learning. (It is worth mentioning at this point that Scotland was one of the first countries to introduce [nature-based] OL widely into formal education[375], and that it is the country that assigns largest grants to the development of the OL concept[376]).

In the context of a formal application of OL, this concept is thus sometimes called Learning Outside the Classroom (LOtC)[377]. Cengelci[378] states that this term expresses an idea that in order to better understand both the everyday life and abstract concepts, it is necessary to leave the building of a school, kindergarten or university which is out of touch with the reality. When for example pupils learn about a place of great natural interest, they should take their maps and compasses, find this place and visit it, and when they learn about a plant, they should take a measure or a magnifying glass and study this plant thoroughly.

Cengelci[379] underlines that in this context the OL concept meets ICT tools. On the one hand, they are currently becoming the most multitasking tools that allow to study the world, and on the other hand, they are the most mobile carriers of information that make it possible to learn everywhere, also outside, in places without access to electricity or so remote that it is impossible to move a pile of books or notes to them.

Quoting Allison, Carr and Meldrum[380], the OL concept is thus a certain "educational approach that aims to explore and develop understanding of different subject topics and also, thereby, of connections between them". To further use these authors' conclusions, this approach "refers to practical and/or experiential activities undertaken primarily outdoors. This is a broad conceptualisation which may include learning in the school grounds and in nearby

374. S. Chin-Shyang & C. Mei-Ju, op. cit., p. 158.
375. M. Thorburn & P. Allison, Are we ready to go outdoors now? The prospects for outdoor education during a period of curriculum renewal in Scotland. *Curriculum Journal, **21***, p. 100 (2010).
376. Learning outdoors fund aims to open up the outdoors. *Education Journal, **142***, p. 10 (2012).
377. S. Waite, op. cit., p. 413.
378. T. Cengelci, op. cit., pp. 1836-1837 (2013).
379. Ibidem, p. 1837.
380. P. Allison, D. Carr & G. Meldrum, Potential for excellence: interdisciplinary learning outdoors as a moral enterprise. *Curriculum Journal, **23***, p. 46 (2012).

locations"[381]. As unambiguously showed by Fuller[382], the learning must, however, always be based on first-hand experience.

It is thus clear to see that the OL concept matches the constructivist conceptions of learning[383], similarly to the TEL described in Chapter 1. What is more, as indicated by Figure 2.1., the OL concept is also based on two other theoretical initiatives:

- The Environmental Education Model created by Palmer, which can be described as an "instruction directed toward developing a citizenry prepared to live well in a place without destroying it. Environmental education can occur both inside and outside the classroom"[384].
- The Experiential Learning Theory formulated by Kolb, which defines learning as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience"[385].

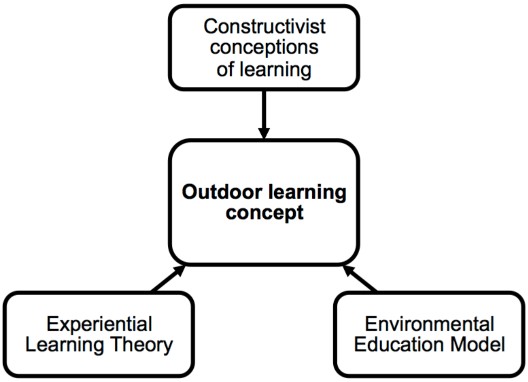


Figure 2.1. The theory base for the outdoor learning concept. Source: own work based on: P. Smeds, E. Jeronen & S. Kurppa, Rural camp school eco learn – outdoor education in rural settings. *International Journal of Environmental and Science Education, **6***, p. 271 (2011).

What is more, Thorburn and Allison[386] notice that the OL concept matches the idea of holistic learning. These authors add that OL is "designed to support the new holistic curriculum intentions in a variety of ways, e.g. through mak-

381. Ibidem.
382. I.C. Fuller, Taking students outdoors to learn in high places. *Area, 44*, p. 7 (2012).
383. P. Smeds, E. Jeronen & S. Kurppa, Rural camp... op. cit., pp. 270-271.
384. Ibidem, p. 270.
385. Ibidem, p. 271.
386. M. Thorburn & P. Allison, Are we ready... op. cit., p. 106.

ing greater connections with literacy, numeracy, and health and wellbeing"[387]. However, the application of OL as a holistic pedagogy is very often hindered in many aspects. In this context, researchers enumerate the following list of barriers:

- "Accessibility, time, ease of use and ownership of outdoor spaces.
- Place and value of OL in the culture and ethos of the setting.
- Perceptions of team, parent and families in terms of risk/litigation/benefits.
- Overemphasis on health and safety.
- Staff knowledge, understanding, confidence and competence.
- Reluctance to use or engage in community spaces.
- Lack of resources; suitable for wet/cold weather.
- Rigid rations and lack of flexibility.
- Weather conditions"[388].

Shawket[389] observes that when tackling the above-mentioned impediments, six design principles for educational environments formulated by Mary Fritz may come in handy. They are presented in Table 2.1.

To sum up the considerations in this paragraph, it has to be underlined that OL is more and more powerful when entering formal education. It is a very desired form of learning because pupils in the city suffer from a very large deficit of contact with nature. Furthermore, OL gives pupils a chance to learn in real conditions or simply outdoors. Very importantly for the considerations in this book, no special conditions are necessary in order to apply OL; it is sufficient to use a park in the city or school green areas. Obviously, OL undergoes numerous limitations, such as those linked to the weather or pupils' safety, to name just a few. As a result, OL should be perceived as an extension of learning in the classroom or at home. The park is supposed to become a place that develops the topics presented at school or a healthy and relaxing, optimum for short, space for completing school tasks[390]. Most importantly for the analyses in this book, however, the OL idea can become reality more and more frequently because of the dissemination of ICT tools. Their mobility makes it possible to use them in OL, both as tools for getting

387. M. Thorburn & P. Allison, Analysing attempts… op. cit., p. 423.
388. I.M. Shawket, Educational methods instruct outdoor design principles: contributing to a better environment. *Procedia Environmental Sciences*, ***34***, p. 224 (2016).
389. Ibidem.
390. D. O'Reilly, op. cit., p. 57.

Table 2.1. Design principles for educational environments. Source: own work based on: I.M. Shawket, Educational Methods Instruct Outdoor Design Principles: Contributing to a Better Environment. *Procedia Environmental Sciences, **34***, p. 224 (2016).

Mary Fritz's design principle	Shawket's Comment
Design Principle 1: "The learning environment should enhance teaching and learning and accommodate the needs of all learners".	**Comment 1:** "Traditional large group, teacher cantered instruction is being replaced with a variety of tactics that increase student involvement, engaging learners into an active participatory process of doing rather than receiving and recreating".
Design Principle 2: "The learning environment should serve as centre of the community".	**Comment 2:** "Shared use of facility space, integrated curricula, collaborative staffing, and utilizing non-traditional settings such as museums, zoos, and parks strengthen a community's sense of identity, and engage multiple generations in dialog of their unique educational issues".
Design Principle 3: "The learning environment should result from a planning and design process involving all stakeholders".	**Comment 3:** "The planning and design of public schools is an inviting forum for modelling the ways that students should learn: through collaboration, shared decision making, and democracy".
Design Principle 4: "The learning environment should provide for health, safety and security".	**Comment 4:** "Schools need to be physically, psychologically, and emotionally safe places. Size and scale of the school can affect health and safety by influencing students' and adults' abilities to form personal relationships. Lighting, indoor air quality and the toxicity of materials affect the school's ability to be a comfortable place for learning".
Design Principle 5: "The learning environment should make effective use of all available resources".	**Comment 5:** "School designs can maximize available resources through multipurpose and shared use, technology, and natural/cultural resources to become places that support continuous opportunities for teaching and learning".
Design Principle 6: "The learning environment should allow for flexibility and adaptability to changing needs".	**Comment 6:** "Schools can be expected to continue to evolve and therefore need to have adaptable facilities and flexible attitudes to meet future demands".

to know a given place[391], and carriers of information that allow to learn various types of topics while sitting outside, for example in a park. Thus, OL and TEL discussed in Chapter 1 interpenetrate[392], creating theoretical foundations for the idea of learning in CyberParks developed in this book.

391. S. Waite, op. cit., pp. 414-418.
392. M. Klichowski & C. Patricio, op. cit., pp. 224-225, 231-232.

2.3. Outdoor learning from the perspective of recent studies

In 2010, Harper[393] noticed that topics related to OL started to be empirically researched on a large scale. The OL concept thus ceased to be exclusively an object of theoretical considerations, and became a subject of practical research. As already stressed, the results of studies conducted in this respect show numerous benefits of OL, but also some barriers of OL.

This paragraph will reconstruct them by applying the perspective of this book. Firstly, results related to OL carried out in the city will be selected. Yet, it is worth mentioning at this point that there are data at our disposal that show many advantages of using the OL concept in rural settings, too[394]. Secondly, the results presented will deal with nature-based OL. In this context, it has to be underlined that in the light of the most recent research results OL carried out in natural environments is in every respect (which was theoretically supported by Kaplan as early as back in the 1970s) more beneficial than that carried out in artificial (man-made) environments[395]. For example, Shin, Shin, Yeoun and Kim[396] showed that the fact whether the man is in a natural or man-made setting is very important for human cognitive processes. Those researchers analysed cognitive capabilities of subjects before and after a 50-minute walk. Half of the subjects went on the walk in a forest, and the rest of them took a walk on the streets of the city. It turned out that only the walk close to nature positively influences cognitive processes. Similar results were achieved by Weinstein, Przybylski and Ryan[397], as well as by Nisbet and Zelenski[398]. Furthermore, studies in cognitive neuroscience, for

393. N.J. Harper, Future paradigm or false idol: a cautionary tale of evidence-based practice for adventure education and therapy. *Journal of Experiential Education,* ***33***, p. 39 (2010).
394. P. Smeds, E. Jeronen & S. Kurppa, Rural camp... op. cit., p. 283.
395. A.L.E.V. Cassidy, W.A. Wright & W.B. Strean, op. cit., pp. 30-31.
396. W.S. Shin, C.S. Shin, P.S. Yeoun & J.J. Kim, The influence of interaction with forest on cognitive function. *Scandinavian Journal of Forest Research,* ***26***, pp. 595-598 (2011).
397. N. Weinstein, A.K. Przybylski & R.M. Ryan, Can nature make us more caring? Effects of immersion in nature on intrinsic aspirations and generosity. *Personality and Social Psychology Bulletin,* ***35***, pp. 1315-1329 (2009).
398. E.K. Nisbet & J.M. Zelenski, Underestimating nearby nature: Affective forecasting errors obscure the happy path to sustainability. *Psychological Science,* ***22***, pp. 1101-1106 (2011).

example those conducted by Henderson, Zhu and Larson[399] or Sofer, Crouzet and Serre[400], show that the human brain functions in a completely different way depending on whether the man carried out cognitive tasks in a natural or man-made setting, and that the former is always more beneficial for it. Nature-based OL is thus desirable not only due to the nature-deficit disorder common among contemporary city dwellers, but also mainly because it is incredibly effective.

2.3.1. Selected recent studies and the benefits of outdoor learning

Black[401] notices that "the benefits of OL have been widely researched and are generally considered to provide depth to the curriculum and make an important contribution to students' physical, personal and social education". The results of a meta-analytical review carried out by Mutz and Muller[402] point to, for example, the following mental health benefits of OL:

- A more positive self-concept.
- Increased self-esteem.
- Improved cognitive autonomy.
- Reduced school truancy.
- More prosocial behaviour.
- The approval of nature protection.
- Increased group cohesion.
- Prejudice reduction.
- Abstinence in regard to substance use.

A more general meta-analysis by Dillon[403] distinguishes six groups of benefits of OL:

1. Health and well-being benefits.
2. Changing attitudes and behaviours.

399. J.M. Henderson, D.C. Zhu & C.L. Larson, Functions of parahippocampal place area and retrosplenial cortex in real-world scene analysis: an fMRI study. *Visual Cognition, **19***, pp. 910-927 (2011).
400. I. Sofer, S.M. Crouzet & T. Serre, Explaining the timing of natural scene understanding with a computational model of perceptual categorization. *PLoS Computational Biology, **11***, pp. 1-20 (2015).
401. R. Black, op. cit., p. 6.
402. M. Mutz & J. Muller, Mental health benefits of outdoor adventures: results from two pilot studies. *Journal of Adolescence, **49***, p. 106 (2016).
403. J. Dillon, op. cit., pp. 155-161.

3. Self-efficacy and self-worth.
4. Benefits to schools, teachers and the wider community.
5. Developing skills.
6. Increasing knowledge and understanding.

What is interesting, as convincingly shown by Sharpe[404], there is least empirical data in the context of groups linked to cognitive processes (the last two), i.e. those showing "exactly how OL strengthens the building blocks to learning". Due to the key character of this thread for the considerations in this book, it will be underlined most in reconstructions of this paragraph.

In the context of benefits from group one, Tardona, Bozeman and Pierson conducted a very interesting study recently[405]. They prepared a programme based on the OL concept, carried out in a park with 1350 elementary school students. The programme assumed learning in a park both about its nature, and the history and culture of its surroundings. Additionally, students were equipped with pedometers that measured the number of their steps and showed statistics of their physical activity. The results of the programme unanimously showed that not only is this type of OL in a park beneficial as far as knowledge is concerned, but above all it considerably increases the level of physical activity, which substantially improves pupils' health.

It has to be noted, however, that physical activity does not just improve physical health. Results of numerous studies show that there is a connection between physical activity and mental health[406]. For this reason, many reports about benefits from group two and three, i.e. showing that OL positively changes attitudes and behaviours, and increases one's self-efficacy and self-worth, can be found. For example, a study by Benton[407] shows that OL – in most general terms – evokes very positive emotions. 93 pupils from a primary public school took part in this study. For six months, they had classes not only at school, but also in parks. As shown based on the interviews that were conducted with the participants, such a form of OL is very relaxing for

404. D. Sharpe, Independent thinkers and learners: a critical evaluation of the "Growing Together Schools Programme". *Pastoral Care in Education, **32***, p. 199 (2014).
405. D.R. Tardona, B.A. Bozeman & K.L. Pierson, A program encouraging healthy behavior, nature exploration, and recreation through history in an urban national park unit. *Journal of Park & Recreation Administration, **32***, pp. 73-82 (2014).
406. M. Lyngas Eklund, I. Ruud & E.K. Grov, op. cit., pp. 6-9.
407. G.M. Benton, The role of intrinsic motivation in a science field trip. *Journal of Interpretation Research, **17***, pp. 71-82 (2013).

pupils, gives them a lot of joy and increases their motivation to cooperate. As a consequence of all this, pupils are incredibly keen to learn. This researcher thus concludes that "emotion is the key to cognition"[408]. Similar results were collected by Mutz and Muller[409] in the context of youths and young adults. Moreover, Moldovan and Enoiu[410] used sociometric tests to study a group of 13 pupils during 6 sessions of park activities and proved that OL contributes to decreasing egotism, and developing mutual help, group cooperation, taking responsibility, inner trust, tolerance and self-control.

Empirical studies also confirmed the real nature of benefits of OL to schools, teachers and the wider community (group four of benefits). Sharpe's studies[411] can be an example of research in this context, where it was not only children applying OL, but also their teachers and parents/carers who took part. For instance, the results show that thanks to OL pupils change their attitude towards greenery and what they eat; they start caring about the nature in their surroundings (especially in the vicinity of their school) and eat rationally, taking into account whether the food is healthy and produced in an eco-friendly way. OL also builds a different type of relation between them, their teachers and the local community, based on joint and equal actions for the growth and protection of the local environment.

From the perspective of the considerations in this book, the most interesting type of benefit is obviously that linked to "cognitive engagement with OL", to quote Green[412], i.e. that related to developing skills, increasing knowledge and understanding (group five and six of benefits).

Excellent research that shows this type of benefits is undoubtedly the one carried out by Christie, Beames and Higgins[413], where a programme for teaching maths and geography was created based on a combination of indoor and outdoor learning. This programme was implemented for 7 months and over 1500 students from three secondary schools took part in it. The researchers used three methods to assess the programme: participant observation, questionnaire and group interviews. It turned out that OL not only contributed to increased knowledge and competence in maths and geography, but also actually developed pupils' critical thinking skills.

408. Ibidem, p. 79.
409. M. Mutz & J. Muller, op. cit., pp. 108-113.
410. E. Moldovan & R.S. Enoiu, op. cit., p. 28-32.
411. D. Sharpe, op. cit., pp. 200-206.
412. M. Green, op. cit., p. 190.
413. B. Christie, S. Beames & P. Higgins, op. cit., pp. 424-433.

A different study conducted by Smeds, Jeronen and Kurppa[414] compared the results of indoor learning, a combination of indoor and outdoor learning, and OL. As the analyses showed, indoor learning brought the worst results! 106 fifth-year pupils from four different primary schools took part in this experiment. They were assigned to three intervention groups:

- Classroom (indoor learning).
- Classroom and farm (a combination of indoor and outdoor learning).
- Farm (OL).

These researchers stated that "the first represents traditional classroom learning, including its learning methods and materials. Group B allowed exploring possible synergy effects between learning environments by combining traditional classroom learning with a visit to the authentic learning environment for the subject taught: a farm. Group C represents learning only in an authentic learning environment on farm, where theory and practice of the subject are combined in the genuine surrounding by genuine actors and activities. [...] The interventions were built up of three separate sequential lessons kept within two weeks"[415].

Smeds, Jeronen and Kurppa[416] conducted both a pre-learning test, a post-learning test, and a five-month-delayed test, which distinguishes their study as compared to other experiments carried out in this context. Figure 2.2. shows that the worst increase in knowledge and competence, as well as their worst durability, was observed in the context of indoor learning. Yet, a similar increase in knowledge and competence was observed in the context of a combination of indoor and outdoor learning, and OL; however, the knowledge and competence gained through the combination of indoor and outdoor learning turned out to be of higher durability.

The poor results for indoor learning as compared to OL's results can be explained by reference to a very recent and incredibly simple study conducted by Volta, Fasano, Cerasa, Mangone, Quattrone and Buccino[417] within the cognitive neuroscience paradigm. 18 healthy subjects (aged 19–28) took part in this study. The study was conducted using the fMRI method. While lying in the scanner, each subject watched two films:

414. P. Smeds, E. Jeronen & S. Kurppa, Farm education and the value of learning in an authentic learning environment. *International Journal of Environmental and Science Education, **10***, pp. 388-397 (2015).
415. Ibidem, p. 387.
416. Ibidem, pp. 391-398.
417. R.D. Volta, F. Fasano, A. Cerasa, G. Mangone, A. Quattrone & G. Buccino, Walking indoors, walking outdoors: an fMRI study. *Frontiers in Psychology, **6***, pp. 2-8 (2015).

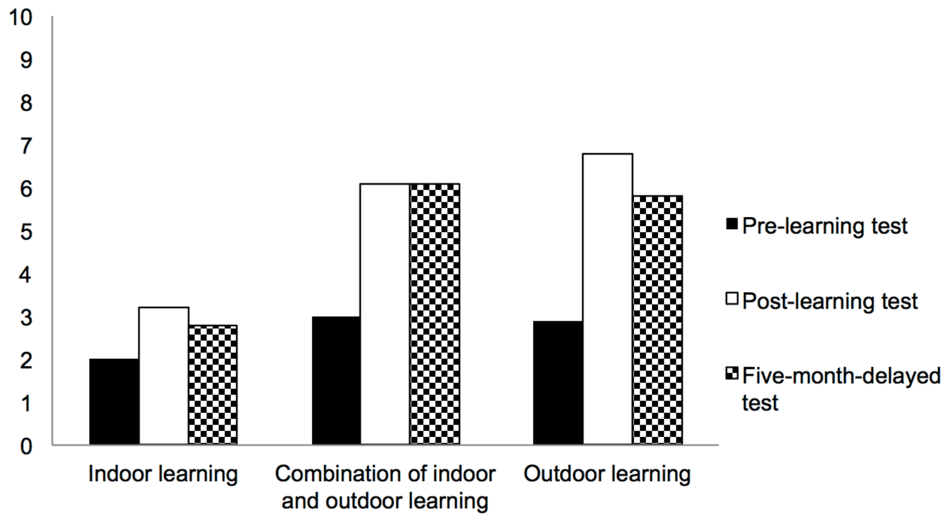


Figure 2.2. A comparison of the results of indoor learning, a combination of indoor and outdoor learning, and outdoor learning. The 0-10 scale refers to the level of knowledge and competence. In this study, apart from a pre-learning test and a post-learning test, a five-month-delayed test was also conducted. The largest increase in knowledge and competence is characteristic of outdoor learning, and its durability is highest for the combination of indoor and outdoor learning. Indoor learning is characterised with the worst increase in knowledge and competence, and their worst durability. Source: own work based on: P. Smeds, E. Jeronen & S. Kurppa, Farm education and the value of learning in an authentic learning environment. *International Journal of Environmental and Science Education, 10*, p. 392 (2015).

– The open space video clip showed a countryside view (Figure 2.3A).
– The narrow space video clip showed a narrow corridor (Figure 2.3B).

As the researchers concluded, "in both the videos depicting a space, the scene was filmed while the cameraman was actually walking in the countryside or in the corridor. In this way, the observation of these videos gave participants the feeling of walking into the observed space"[418]. Moreover, a rolling cylinder was placed under subjects' feet (Figure 2.3C). In this way, while watching the films, the subjects were able to simulate movements that they do when they are actually out on a walk[419].

Figure 2.4 shows that the researchers confirmed that different space features in which walking occurs are differently coded[420]. Human brain activity is different in some respects when a person is on a walk and processes images

418. Ibidem, p. 3.
419. Ibidem, pp. 3-4.
420. Ibidem, pp. 4-8.

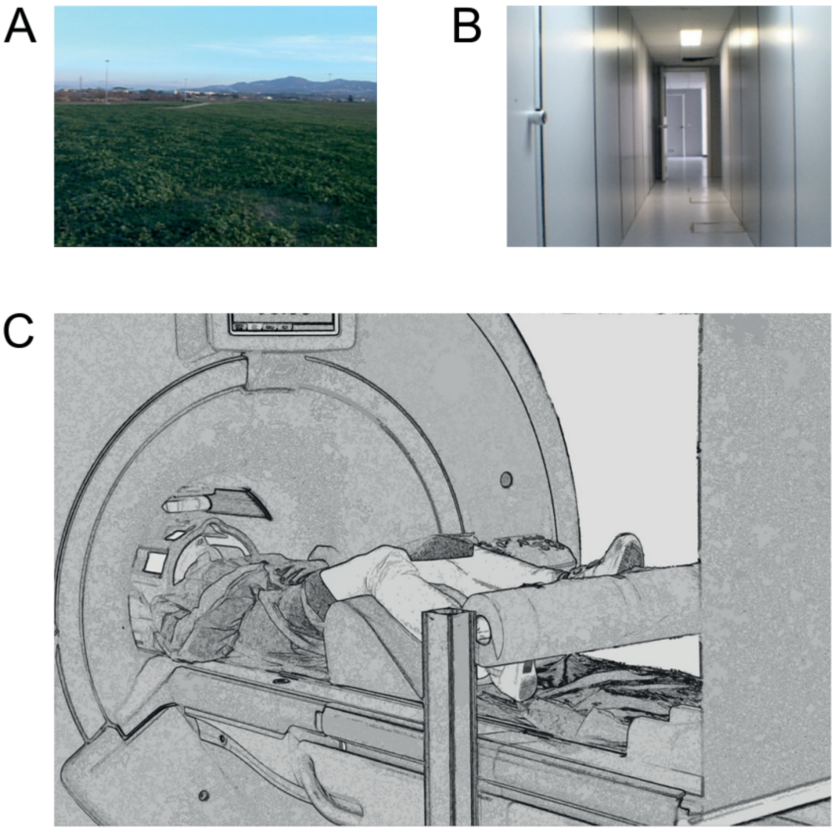


Figure 2.3. Stimuli and experimental setup used in the study by Volta, Fasano, Cerasa, Mangone, Quattrone and Buccino. (A) A still frame taken from the open space video clip (a countryside view). **(B)** A still frame taken from the narrow space video clip (a narrow corridor). **(C)** An fMRI scanner with a rolling cylinder. Source: R.D. Volta, F. Fasano, A. Cerasa, G. Mangone, A. Quattrone& G. Buccino, Walking indoors, walking outdoors: an fMRI study. *Frontiers in Psychology,* **6**, pp. 3-4 (2015). Under the terms of the Creative Commons Attribution License.

presenting an open space, as compared to those presenting an indoor space. This is mainly the result of a different complexity of these spaces. In an open space, there are more stimulating objects, while the narrow space requires a different, more precise motor coordination. However, an additional analysis of the schemes of brain activity under these two conditions also showed that the open space is simply more interesting for the man; it creates interest; the man wants to get to know it. What is more, the open space has a soothing sort of effect, encouraging cognitive activity as such. On the other hand, the indoor, narrow space is treated by the human brain as a temporary space that is not aimed at growth but at relax or as a communication track that requires certain motor control and little cognitive sensitivity.

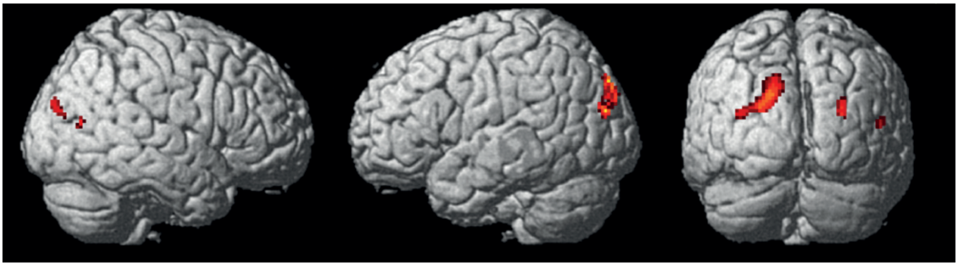


Figure 2.4. Human brain activity while taking a walk in an indoor space as compared to an open space. Source: R.D. Volta, F. Fasano, A. Cerasa, G. Mangone, A. Quattrone& G. Buccino, Walking indoors, walking outdoors: an fMRI study. *Frontiers in Psychology,* ***6***, p. 5 (2015). Under the terms of the Creative Commons Attribution License.

It is worth adding, however, that the results of an experiment by Nadelson and Jordan[421] show that OL is not only very effective as far as the activities completed within it are concerned, but it can also contribute to increased effectiveness of learning as such, also indoor learning. When proving this correlation, these researchers tested 111 sixth-grade students participating in an all-day event that took place during a regular school day at a local city park (the activities were mostly related to animals inhabiting the area). After these classes within the OL frame, they interviewed the students on their opinions about this all-day event. More interviews followed after a month. The results unambiguously show that students not only assessed OL very highly right after the classes, but that these one-day classes in a park were enough for the students to extremely intensify their involvement in investigating the topic further already through indoor learning.

The positive influence of OL on indoor learning is yet only observed in case of a combination of indoor and outdoor learning. Studies show that students who learn exclusively out of school for a longer time start to perceive learning at school as completely senseless. For example, this correlation was shown in a study conducted by Dettweiler, Unlu, Lauterbach, Legl, Perikles and Kugelmann[422]. These researchers sent letters to participants of a six-months' over-sea's educational programme, asking them to answer several questions related to their adaption to a "normal" life. The letter was replied to by 56 peo-

421. L.S. Nadelson & J.R. Jordan, Student attitudes toward and recall of outside day: an environmental science field trip. *The Journal of Educational Research,* ***105***, pp. 223-230 (2012).

422. U. Dettweiler, A. Unlu, G. Lauterbach, A. Legl, S. Perikles & C. Kugelmann, Alien at home: adjustment strategies of students returning from a six-months over-sea's educational programme. *International Journal of Intercultural Relations,* ***44***, pp. 75-86 (2015).

ple. The analysis of replies showed, among others, that such a radical form of OL (called adventure education/learning) completely changed the way those students perceived school. The students believed, for example, that "school on board was much more interesting because a lot of what one had to learn made immediate sense"[423]. Learning at school, on the other hand, is detached from a real context. After they tried learning in a real context, learning at school lost sense for them completely.

2.3.2. Selected recent studies and barriers of outdoor learning

Black[424] observes that the barriers of OL can be divided into three (to some extent interrelated) groups:

- Cultural.
- Logistical.
- Institutional.

Dillon[425] adds that the social perception of OL is often saturated with stereotypical thinking (cultural barriers), the organization of OL is formally complicated (logistical barriers), and schools (including teachers and staff) are completely unprepared for OL (institutional barriers). This observation is confirmed by the results of numerous studies.

In the context of cultural barriers, Dallat, Salmon and Goode[426] carried out a qualitative analysis of publicly available risk assessments undertaken by schools conducting OE programmes and discovered that, for example, there is still not enough solid information about the risks resulting from applying OL. Due to this situation, the risks are often overestimated. Most frequently, OL is thus stereotypically perceived as dangerous for students (more dangerous than indoor learning). Research by Miller and Barrio Minton[427] shows that this stereotypical opinion also affects teachers' thinking. The teachers (*N*=6) that they interviewed who use OL in a very safe and

423. Ibidem, p. 80.
424. R. Black, op. cit., p. 6.
425. J. Dillon, op. cit., pp. 161-163.
426. C. Dallat, P.M. Salmon & N. Goode, All about the teacher, the rain and the backpack: the lack of a systems approach to risk assessment in school outdoor education programs. *Procedia Manufacturing, **3***, pp. 1159-1163 (2015).
427. R.M. Miller & C.A. Barrio Minton, Experiences learning interpersonal neurobiology: an interpretative phenomenological analysis. *Journal of Mental Health Counseling, **38***, pp. 49-58 (2016).

verified environment declared that they still experience a lot of stress when applying OL with students.

On the other hand, for example logistical barriers were empirically addressed by Cengelci[428]. Using the method of semistructured interviews in his study on 15 teachers, he proved that teachers who organize OL come across many economic problems and bureaucratic obstacles at school. This situation often makes it impossible for them to apply OL or limits it substantially.

The most extreme results seem to be those with regard to institutional barriers. They show that teachers are not prepared to apply OL. As a result, as demonstrated by Schumann and Sibthorp[429] who studied over 500 subjects, they often do not believe that they can use OL effectively. What is more, very frequently they completely do not understand the essence of OL. For example, Tan and Atencio[430] conducted questionnaire surveys with 84 teachers and in-depth interviews with 14 teachers, and discovered that those teachers do not understand that OL is linked to place-based pedagogy at all. They treat OL in parks or greens spaces basically exclusively as a motor activity out in the fresh air in the form of a walk or game. To paraphrase Smeds, Jeronen and Kurppa[431], it can be said that they completely do not notice that OL is a fascinating cognitive activity that is "a product of time, place, and environment".

Conclusions

This chapter has shown that in the contemporary world where city dwellers suffer from a chronic deficit of movement and nature the OL concept, i.e. the idea of learning not only in the classroom or at home, but also in school grounds, parks, protected areas etc., becomes more and more popular, also in formal systems of education. Yet, the implementation of OL results in benefits that are not only linked to eliminating the consequences of movement and nature deficits. Many studies show that by placing cognitive activity of a student in a nature-based environment, OL creates ideal conditions for their cognitive development. Unfortunately, the implementation of the OL concept in educational systems still seems to be ineffective. The widely understood

428. T. Cengelci, op. cit., pp. 1838-1840.
429. S. Schumann & J. Sibthorp, The development and scaling of the teaching outdoor education self-efficacy scale. *Research in Outdoor Education, **12***, pp. 80-98 (2014).
430. Y.S.M. Tan & M. Atencio, op. cit., pp. 28-32.
431. P. Smeds, E. Jeronen & S. Kurppa, Farm education... op. cit., p. 399.

education is not prepared for OL. In particular, problems with applying OL are experienced by teachers, as shown in study results. And, as demonstrated by Tal, Lavie Alon and Morag[432], it is the functioning of teachers that determined the effectiveness of OL (it is similar with TEL, as presented in Chapter 1).

Smeds, Jeronen and Kurppa thus demonstrate that the system of educating teachers needs to be thoroughly rebuilt, so that teachers learn how to use the OL concept effectively. Those authors thus write: "Teachers, the educators, are taught at university about the best ways to teach and how the learning environment for this is best arranged in terms of place and other aspects of environment. They will most likely follow these guidelines in their teaching, applying what they have been taught is the best way to teach, in the environment they have been informed is best. Through this and other instruction, pupils learn how to learn, thereby accumulating half of their learning preferences. Accordingly, if pupils are not taught how to learn in other settings than a classroom, they will not be able to utilise all of the authentic learning environments' possibilities. Neither is this possible if the teachers have not been taught to teach in diverse learning environments. Teacher education has a crucial role in forming education practices, alongside views of what learning environments are best for learning, what the best teaching methods are, and how pupils learn best[433]".

To sum up this chapter, it has to be underlined very clearly that due to the fact that OL consists in learning about a given place of natural interest, as well as in learning in that place itself, OL is in some sense linked to TEL discussed in Chapter 1 (and more precisely, to smart learning or smart education). It is ICT tools that currently make it possible for students to examine the world and are mobile carriers of information that allow students to learn virtually anywhere. OL is thus a second (TEL being the first) pillar of the idea of learning in CyberParks. The combination based on linking TEL and OL (technology-enhanced outdoor learning) will be discussed in the next chapter.

432. T. Tal, N. Lavie Alon & O. Morag, Exemplary practices in field trips to natural environments. *Journal of Research in Science Teaching, **51***, p. 430 (2014).

433. P. Smeds, E. Jeronen & S. Kurppa, Farm education... op. cit., p. 399.

CHAPTER 3

Technology-enhanced outdoor learning

Introduction

Cooley, Holland and Cumming[434] notice, which in a sense was mentioned in Chapter 2, that everything located outdoors and close to nature is "a unique environment for students". As added by Land and Zimmerman[435], such surroundings are a dynamic context for learning filled with all kinds of objects that stimulate cognitive activity. (It has to be underlined, however, that obviously a non-nature-based surrounding is also equipped with numerous cognitively stimulating – – though not so much from the perspective of contemporary city dwellers – objects, which is why, for example, on-street activity is also an important form of OL, as shown by Samadi, Yunus, Omar and Bakri [436]. What is interesting, according to Perez-Sanagustin, Parra, Verdugo, Garcia-Galleguillos and Nussbaum[437], the potential of natural surroundings understood in this way is fostered (or more accurately: enhanced) by ICT tools. Su and Cheng[438] even claim that these tools "offer the opportunity to embed learning in a natural environment".

434. S.J. Cooley, M.J. Holland & J. Cumming, Introducing the use of a semi-structured video diary room to investigate students' learning experiences during an outdoor adventure education groupwork skills course. *Higher Education: The International Journal of Higher Education and Educational Planning,* ***67***, p. 119 (2014).
435. S.M. Land & H.T. Zimmerman, Socio-technical dimensions of an outdoor mobile learning environment: a three-phase design-based research investigation. *Educational Technology Research and Development,* ***63***, p. 233 (2015).
436. Z. Samadi, R.M. Yunus, D. Omar & A.F. Bakri, Experiencing urban through on-street activity. *Procedia – Social and Behavioral Sciences,* ***170***, pp. 653-658 (2015).
437. M. Perez-Sanagustin, D. Parra, R. Verdugo, G. Garcia-Galleguillos & M. Nussbaum, op. cit., p. 73.
438. C.-H. Su & C-H. Cheng, A mobile gamification learning system for improving the learning motivation and achievements. *Journal of Computer Assisted Learning,* ***31***, p. 268 (2015).

Pierre[439] explains this correlation in a spectacular and slightly perverse way with the following words: “on one hand, digital learning technologies can be used to complement and extend real-world outdoor learning – in taking and sharing of photos, videos and audio recordings, using art and design software and Internet searches, creating blogs, and so on. On the other hand, the patterns of thinking, ways of learning, and mindsets of the Net Generation and other digitally inclined learners can be addressed in the ways in which we think about the natural world as a learning resource. In this vein [...] nature might be understood as a giant, multisensory, multimedia, living museum, real-world Wikipedia, dispersed wilds akin to the Internet, or outdoor web of nature”. What is more, as further explained by this author, this type of immersion in the natural environment helps people “recover spiritually and physically from the effects of computers, cell phones, and the Internet, moving from the stress of constant interface with digital technologies in the virtual world to the quiet calmness and slower pace of the natural world [...]. Outdoor learning involving touch, taste, smell, sound, and sight might make creative use of digital technology [...]. In these ways, a healthy balance, creative relationship, and synergy may develop between learning in the digital and natural worlds [...]. The digital resources of the Internet can be used to learn about the physical world. Web-based reference software, blog sites, videos, and courseware can be used, for example, to look up wildlife behaviour and habitat, explore place-based history, urban green planning, or understand particular natural ecosystems and their elements [...]. From a digitally minded perspective, nature can be seen as a giant living library or museum filled with an infinite variety of interesting, touchable, see-able, feel-able, smell-able, and hear-able knowledge, facts, and experiences immediately available to learners”[440].

At present, a sort of reincarnation, or some type of promotion, of nature-based OL takes place via ITC tools, underlining the feedback between new technologies and nature[441]. On the one hand, mobile ICT tools stimulate (especially city dwellers) to explore nature, and on the other hand, the use of ICT close to nature to some extent eliminates negative effects of the perma-

439. W. Pierre, Greening the net generation: outdoor adult learning in the digital age. *Adult Learning,* ***24***, p. 155 (2013).

440. Ibidem, p. 155.

441. G. Aydin, The effects of computer-aided concept cartoons and outdoor science activities on light pollution. *International Electronic Journal of Elementary Education,* ***7***, pp. 142-156 (2015).

nent connection of human brains to the Internet (described in Chapter 1) and the permanent deficit of nature and movement characteristic of city dwellers (shown in Chapter 2). Moreover, as noticed by Benton[442], ICT tools open OL to the disabled, for example blind or visually impaired, thus increasing the group of potential participants of OL and its inclusiveness.

Such a combination of ICT tools and OL is called technology-enhanced outdoor learning (TEOL) by Veletsianos, Miller, Eitel, Eitel, Hougham and Hansen[443]. As show in the introduction, TEOL is a theoretical framework for the concept of learning in CyberParks presented in this book and is part of the idea of smart education, which in turn is an educational solution aimed at functioning in a smart city. What exactly is smart city and smart education then? How should we understand CyberParks and the idea of learning in CyberParks? Finally, do scientific reports actually point to the educational potential of CyberParks? This chapter is an attempt at answering these questions. In the first paragraph the smart city concept will be shown. Subchapter 2 will present an interpretation of smart education. Then the current knowledge on CyberParks concepts will be described. Results of the most recent research to some extent linked to the idea of learning in CyberParks (or, more broadly, to TEOL) will also be presented. The last part of this chapter will show the largest theoretical problem of the concept of learning in CyberParks, which will become the object of empirical analyses in the next, research part of the book.

3.1. Smart city concept

Currently, over a half of the world's population lives in cities[444]. The 50% threshold for the world population was exceeded in 2007[445], and in 2014

442. K. Benton, Developing a multi-sensory outdoor education program. *Insight: Research & Practice in Visual Impairment & Blindness,* ***4***, p. 177 (2011).
443. G. Veletsianos, B.G. Miller, K.B. Eitel, J.U. Eitel, R.J. Hougham & D. Hansen, Lessons learned from the design and development of technology-enhanced outdoor learning experiences. *TechTrends: Linking Research and Practice to Improve Learning,* ***59***, p. 80 (2015).
444. R. Khatoun & S. Zeadally, Smart cities: concepts, architectures, research opportunities. *Communications of the ACM,* ***59***, p. 46 (2016).
445. K. Kourtit, P. Nijkamp & D. Arribas, Smart cities in perspective – a comparative European study by means of self-organizing maps. *Innovation: The European Journal of Social Sciences,* ***25***, p. 229 (2012).

this value already rose to almost 55 per cent[446]. In Europe, the threshold was exceeded as early as in 1950, and was over 75% in 2010. What is more, it is estimated that by 2050 at least 85 per cent of Europeans will have lived in European cities[447]. As observed by Kourtit, Nijkamp and Arribas[448], such trends in the development of civilization are based on the so-called third revolution in urbanization in our world. The first revolution took place in antiquity when first cities were built. The second one was a consequence of the Industrial Revolution and was mainly related to the territorial growth of cities and communication between them. The third one started in the post-World War II period, when cities began to develop in a non-passive way, i.e. not only as spaces for settlement, but also as centres that simulated creativity, innovation, unconventional solutions and places aiming at knowledge. However, as shown by Quak, Lindholm, Tavasszy and Browne[449], this functional development of cities is also accompanied by its structural degeneration, for example linked to the fact that the air is more and more contaminated, there is less and less greenery, and less and less space for physical activity in cities.

Urban planners, landscapers and architects thus pose a question about what can be done for the growth of cities to be also accompanied by a multi-faceted increase in the quality of life of their dwellers[450]? They ask what can make a city more liveable[451]? All answers circulate around one category: ICT. It is with them that a city can transform into a smart city[452].

The concept of smart city was probably first shown in 1994, and since 2011 an incredible increase in publications on this idea has been observed, as

446. H. Quak, M. Lindholm, L. Tavasszy & M. Browne, From freight partnerships to city logistics living labs – giving meaning to the elusive concept of living labs. *Transportation Research Procedia, **12***, p. 462 (2016).
447. A. Caragliu, C. Del Bo & P. Nijkamp, Smart cities in Europe. *Journal of Urban Technology, **18***, pp. 65-66 (2011).
448. K. Kourtit, P. Nijkamp & D. Arribas, op. cit., p. 229.
449. H. Quak, M. Lindholm, L. Tavasszy & M. Browne, op. cit., p. 462.
450. G. Mone, The new smart cities. *Communications of the ACM, **58***, p. 20 (2015).
451. J.R. Gil-Garcia, T.A. Pardo & T. Nam, What makes a city smart? Identifying core components and proposing an integrative and comprehensive conceptualization. *Information Polity: The International Journal of Government & Democracy in the Information Age, **20***, p. 61 (2015).
452. I. Semanjski & S. Gautama, Smart city mobility application – gradient boosting trees for mobility prediction and analysis based on crowdsourced data. *Sensors, **15***, p. 15975 (2015).

well as attempts at applying it, which is clearly supported by the European Union[453]. As shown by van den Bergh and Viaene[454], the smart city concept makes reference to some earlier concepts of city development such as the digital city, the wireless city and the informational city. In this context, Anthopoulos and Reddick[455] also enumerate the virtual city, the broadband city, the broadband metropolis, the mobile city and the ubiquitous city, whereas Gil-Garcia, Pardo and Nam[456] also mention the intelligent city. However, as noticed by Gomez and Paradells[457], "a formal and widely accepted definition of smart city does not exist". Furthermore, as underlined by Granier and Kudo[458], there is not even any "consensual" definition of the smart city. Singh[459] adds that every paper on the smart city "deals with different parts like smart grid, intelligent transportation system, smart home, smart water, smart medical care, smart food, smart education, smart shopping and so on". It is thus difficult to refer in any way to the whole that the smart city concept is supposed to create.

Without doubt, the essence of the smart city idea is the use of ICT in a way that would make the critical elements of the city become "more intelligent" [460]. Gontar, Gontar and Pamula[461] add that the smart city concept refers to the idea of integrating ICT with any processes taking place in a city, and linked to the urban physical and social infrastructures, in a way that makes it possible to optimise these processes to the maximum,

453. S. Hajduk, The concept of a smart city in urban management. *Business, Management & Education, **14***, p. 36 (2016).
454. J. van den Bergh & S. Viaene, Unveiling smart city implementation challenges: the case of Ghent. *Information Polity: The International Journal of Government & Democracy in the Information Age, **21***, p. 6 (2016).
455. L.G. Anthopoulos & C.G. Reddick, Understanding electronic government research and smart city: a framework and empirical evidence. *Information Polity: The International Journal of Government & Democracy in the Information Age, **21***, p. 102 (2016).
456. J.R. Gil-Garcia, T.A. Pardo & T. Nam, op. cit., p. 62.
457. C. Gomez & J. Paradells, Urban automation networks: current and emerging solutions for sensed data collection and actuation in smart cities. *Sensors, **15***, p. 22875 (2015).
458. B. Granier & H. Kudo, How are citizens involved in smart cities? Analysing citizen participation in Japanese "Smart Communities". *Information Polity: The International Journal of Government & Democracy in the Information Age, **21***, p. 66 (2016).
459. B. Singh, Smart city-smart life – Dubai Expo 2020. *Middle East Journal of Business, **10***, p. 49 (2015).
460. C. Gomez & J. Paradells, op. cit., p. 22875.
461. B. Gontar, Z. Gontar & A. Pamula, Deployment of smart city concept in Poland. Selected aspects. *Management of Organizations: Systematic Research, **67***, p. 41 (2013).

irrespective of whether they are linked to energy, water, buildings, transportation, communications, administrative services or anything else. As shown by the previously quoted Anthopoulos and Reddick[462], all these innovative solutions that build the smart city concept do not have to be exclusively based on ICT. They can also use other sources of innovation, however – as convincingly explained by Abella, Ortiz-de-Urbina-Criado and De-Pablos-Heredero[463] – they are always supposed to use the possibility of applying new technologies in a given context to the maximum and simply improve everyday urban life.

What is more, when thinking about the meaning of the word "smart" in the city context, it is best to give up on its traditional understanding linked to the connotations of the word "intelligent". Yin, Xiong, Chen, Wang, Cooper and David[464] explain that "people usually do not understand differences between a smart city and an intelligent city [...]. Smart means to be able to self-adapt and provide customized interfaces and services to user needs, which is more user-friendly than intelligent, which implies having a quick mind and being responsive to feedback". The smart city has thus to be taken on the one hand as a technology-enabled city (like in case of an intelligent city)[465], on the other hand, however, as a city geared towards people and the human capital[466]. The smart city is thus not an idea of a technologically equipped city, but of a new thinking paradigm, referring to the technologically stimulated growth (or, more accurately: progress) of city dwellers[467].

The researchers state that the smart city is constituted with an interaction of three elements: technology, environment and – most importantly – humans (Figure 3.1)[468]. Of course, as many theoreticians indicate, the quality of this

462. L.G. Anthopoulos & C.G. Reddick, op. cit., p. 99.
463. A. Abella, M. Ortiz-de-Urbina-Criado & C. De-Pablos-Heredero, Information reuse in smart cities' ecosystems. *El Profesional de la Informacion, **24***, p. 839 (2015).
464. C.-T. Yin, Z. Xiong, H. Chen, J.-Y. Wang, D. Cooper & B. David, A literature survey on smart cities. *Science China Information Sciences, **58***, p. 4 (2015).
465. G.H. Popescu, The economic value of smart city technology. *Economics, Management & Financial Markets, **10***, p. 77 (2015).
466. S. Allwinkle & P. Cruickshank, Creating smart-er cities: an overview. *Journal of Urban Technology, **18***, pp. 3-4 (2011).
467. L.G. Cretu, Smart cities design using event-driven paradigm and semantic web. *Informatica Economica, **16***, p. 57 (2012).
468. G. Sagl, B. Resch & T. Blaschke, Contextual sensing: integrating contextual information with human and technical geo-sensor information for smart cities. *Sensors, **15***, p. 17016 (2015).

interaction is determined by the economic context to a great extent[469]. The widely understood economy becomes thus some superior (and superficially invisible) component of the smart city structure[470].

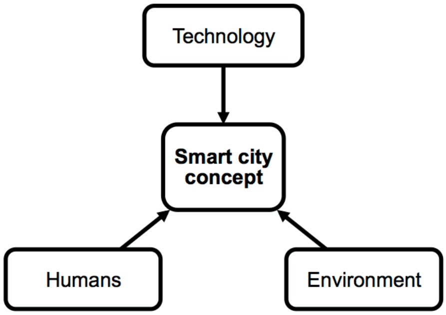


Figure 3.1. Constituent elements in the smart city concept. Source: own work based on: G. Sagl, B. Resch & T. Blaschke, Contextual sensing: integrating contextual information with human and technical geo-sensor information for smart cities. *Sensors,* **15**, p. 17016 (2015).

Many authors create other, more complex lists of significant (and interfering) smart city components. For example, in this context Zubov[471] enumerates the following elements:

- Technology.
- Natural environment.
- People and communities.
- Economy.
- Management and organization.
- Governance.
- Policy.
- Built infrastructure.

Gil-Garcia, Pardo and Nam[472] provide a yet more detailed list of smart city components. These are:

- ICT and other technologies.

469. M.-A. Doran & S. Daniel, Geomatics and smart city: a transversal contribution to the smart city development. *Information Polity: The International Journal of Government & Democracy in the Information Age,* **19**, p. 60 (2014).
470. B. Singh, op. cit., pp. 49-50.
471. D. Zubov, Early warning of heat/cold waves as a smart city subsystem: a retrospective case study of non-anticipative analog methodology. *BRAIN: Broad Research in Artificial Intelligence & Neuroscience,* **6**, p. 44 (2015).
472. J.R. Gil-Garcia, T.A. Pardo & T. Nam, op. cit., pp. 69-70.

- Natural environment and ecological sustainability.
- Built environment and city infrastructure.
- Human capital and creativity.
- Knowledge economy and pro-business environment.
- Public services.
- City administration and management.
- Policies and other institutional arrangements.
- Governance, engagement and collaboration.
- Data and information.

When analysing smart city components, Kraus, Richter, Papagiannidis and Durst[473] created a list of conceptual elements of the smart city. It includes:

- ICT infrastructure and information management.
- Social inclusion of urban residents in public services.
- Social and relational capital.
- High-tech and creative industries.
- Social and environmental sustainability.
- Business-led urban development.

Figure 3.2. shows one of the most popular (and well-defined) models of smart city components. On the one hand, it seems that it shows the fundamental elements of the smart city (technology, living, mobility, people, economy and governance) very well; on the other hand, however, it makes one realize that for the smart city to be truly smart, technologies have to become the background for progress and interaction between the remaining elements instead of being just an aim of their own[474].

Due to the fact that there are many definitions of the smart city and its components are greatly diversified, different approaches to the smart city, or even its different types, are more and more frequently discussed. According to Hajduk[475], for example, there approaches to the smart city can be distinguished (although only the third of them really reflects the connotations of the word "smart"):

- Approach focused on implementing advanced technologies to the tissue of the city (especially sensors, or on the sensoring of the city; the sensors may include: traffic sensors, air pollution sensors, sound sensors,

473. S. Kraus, C. Richter, S. Papagiannidis & S. Durst, Innovating and exploiting entrepreneurial opportunities in smart cities: evidence from Germany. *Creativity & Innovation Management*, ***24***, pp. 602-605 (2015).
474. R. Khatoun & S. Zeadally, op. cit., pp. 46-48.
475. S. Hajduk, op. cit., p. 37.

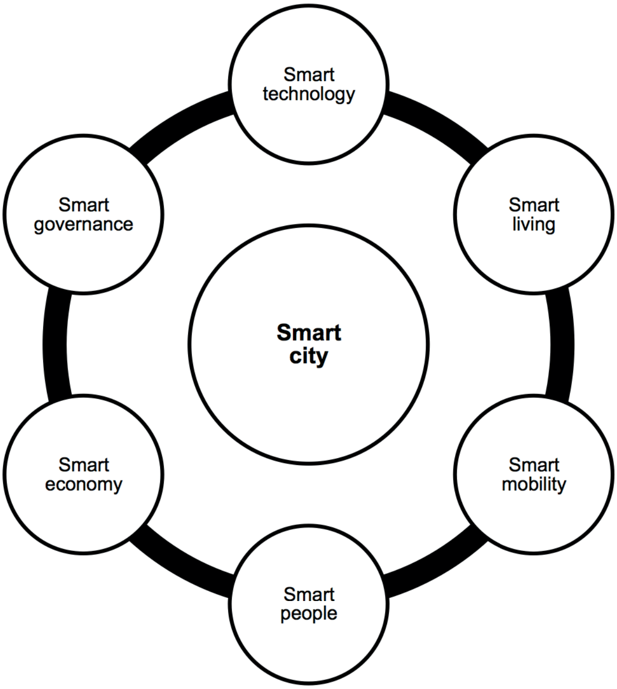


Figure 3.2. Model of smart city components. Source: own work based on: R. Khatoun & S. Zeadally, Smart cities: concepts, architectures, research opportunities. *Communications of the ACM*, ***59***, p. 48 (2016).

humidity sensors[476] or public infrastructures sensors – for example, they monitor buildings, roads or bridges[477]).

- Approach focused on modern ways of protecting and improving the city environment (linked to the so-called green economy[478] and referring mostly to energy savings, alternative energy sources and more efficient transport means[479]).
- Approach focused on innovative transmission of knowledge, increasing the skills of city dwellers and ensuring the intellectual progress of the society (i.e. linked to learning and education).

476. A. Abella, M. Ortiz-de-Urbina-Criado & C. De-Pablos-Heredero, op. cit., p. 840.
477. G.P. Hancke, B. de Carvalho e Silva & G.P. Hancke Jr. The role of advanced sensing in smart cities. *Sensors*, ***13***, p. 394 (2013).
478. R. Ferrara, The smart city and the green economy in Europe: a critical approach. *Energies*, ***8***, p. 4725 (2015).
479. A. Abella, M. Ortiz-de-Urbina-Criado & C. De-Pablos-Heredero, op. cit., p. 839.

Yet, Niaros[480] created a taxonomy of the smart city (Figure 3.3) where he distinguishes its four types (the first two are directed at maximizing the profits of ICT companies, the further two, on the other hand, at the actual increase in the quality of life in the city):

- Corporate smart city – city development is determined by commercial activities of big ICT companies such as Cisco Systems, IBM and Siemens.
- Sponsored smart city – city development is determined by non-commercial projects whose completion, however, is sponsored by ICT firms.
- Resilient smart city – city development is determined by the interests of a given local community and activities of local authorities.

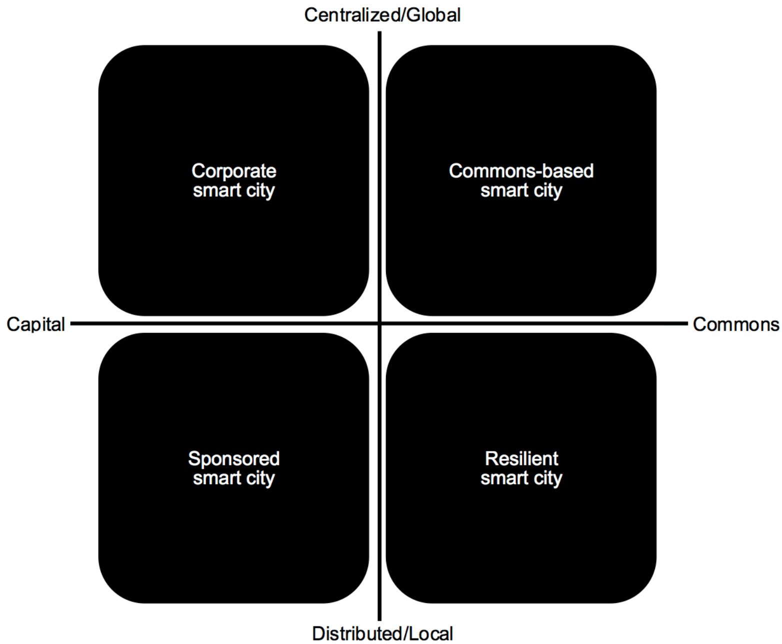


Figure 3.3. Four types of the smart city. The types to the left of the Y-axis (referring to the polarization: centralized/global versus distributed/local control of the ICT infrastructure) are aimed at maximizing the profits of ICT firms; the types to the right of the Y-axis, on the other hand, are aimed at the actual increase in the quality of life in the city. The X-axis refers to polarization: the accumulation or circulation of capital versus the accumulation or circulation of the commons. Source: own work based on: V. Niaros, Introducing a taxonomy of the "smart city": towards a commons-oriented approach? *TripleC (Cognition, Communication, Co-Operation): Open Access Journal for a Global Sustainable Information Society,* ***14***, p. 53 (2016).

480. V. Niaros, Introducing a taxonomy of the "smart city": towards a commons-oriented approach? *TripleC (Cognition, Communication, Co-Operation): Open Access Journal for a Global Sustainable Information Society,* ***14***, pp. 52-59 (2016).

– Commons-based smart city – city development is determined by the interests of the global community and activities taken up in a global perspective.

The definition issues and numerous concepts and interpretations presented are not the only problems with the smart city. This concept is widely criticized. As determined by de Lange[481], "by and large, these criticisms have focused on the ill-defined notion of smartness in smart city visions [...]. What does smart mean and who are actually supposed to be smart?" Moreover, this author also asks whether people in a city based on ICT are smart indeed? Isn't it that such a city sometimes makes them stop to be active and become reactive, following technologically programmed paths, tempted with technologically defined awards; isn't it that they become passive dwellers of a city that is an algorithm of their programmed activities (we would then deal with the smart city without smart people[482])[483]?

The smart city is also criticized for its business dimension. For example, Kuk and Janssen[484] underline that the smart city works in tandem with business, whereas Soderstrom, Paasche and Klauser[485] shows that the smart city is a sort of a business language game. As explained by these authors, life in smart cities is "optimized through technologies provided by IT companies. These companies are the main producers of a discourse about (the benefits of) smart cities that they produce both to describe their activity in the domain and to stage themselves as central actors of this urban management model"[486].

Furthermore, the smart city is a city of a gigantic risk: virtually all cyber-physical things, spaces, infrastructures and people are combined into one

481. M. de Lange, The playful city: using play and games to foster citizen participation. In: A. Skarzauskiene (Ed.), *Social technologies and collective intelligence* (p. 427). Vilnius: Mykolas Romeris University (2015).
482. A. Sofronijevic, V. Milicevic & B. Ilic, Smart city as framework for creating competitive advantages in international business management. *Management,* ***71***, p. 8 (2014).
483. M. de Lange, The smart city you love to hate: Exploring the role of affect in hybrid urbanism. In: D. Charitos, l. Theona, D. Dragona, C. Rizopoulos & M. Meimaris (Eds.), *The hybrid city II: subtle revolutions. Proceedings of the 2nd International Hybrid City Conference* (pp. 77-84). Athens: University Research Institute of Applied Communication (2013).
484. G. Kuk & M. Janssen, The business models and information architectures of smart cities. *Journal of Urban Technology,* ***18***, pp. 39-40 (2011).
485. O. Soderstrom, T. Paasche & F. Klauser, Smart cities as corporate storytelling. *City,* ***18***, p. 307 (2014).
486. Ibidem, p. 309.

system here. Popescul and Radu[487] thus notice that an infection of the system, or some kind of an IT attack, can lead to a catastrophic standstill in the entire city in just one moment (suddenly, all the elements of the system would stop working, such as: hospitals, cars, lighting, traffic lights systems, industrial electronic machines, transport networks, security cameras, food distribution networks, electric heating systems, home routers, set-top boxes, or even home computers or fridges[488]). In addition, the smart city is a colossal system that produces big data[489]. For the city to be actually smart, the system has to include detailed information about the inhabitants, thus it has to technologically follow (often in real-time[490]) their various behaviours, and not only those completed on the Internet, but also those performed out of the Network[491], for example using the so-called surveillance video service (SVS)[492] or camera-fitted drones (what is interesting, drones have invaded the smart city to such an extent that it is recently said that the drone city has been born[493])[494]. Roche[495] thus calls the smart city population hyperlocalized people. A problem emerges here: such multifaceted data forms knowledge that gives unbelievable power[496]. As a result, access to big data becomes a priority context of interest for many types of businesses, also those of criminal or even terrorist nature, that can intercept a huge amount of personal data with just one attack on the system[497].

487. D. Popescul & L.D. Radu, Data security in smart cities: challenges and solutions. *Informatica Economica, **20***, p. 32 (2016).
488. D. Zubov, op. cit., p. 43 (2015).
489. L. Batagan, Smart cities and sustainability models. *Informatica Economica, **15***, p. 80 (2011).
490. M.N.K. Boulos & N.M. Al-Shorbaji, On the Internet of Things, smart cities and the WHO Healthy Cities. *International Journal of Health Geographics, **13***, p. 2 (2014).
491. A.S. Elmaghraby & M.M. Losavio, Cyber security challenges in smart cities: safety, security and privacy. *Journal of Advanced Research, **5***, pp. 491-492 (2014).
492. R. Zheng, C. Yao, H. Jin, L. Zhu, Q. Zhang & W. Deng, Parallel key frame extraction for surveillance video service in a smart city. *PLoS ONE, **10***, pp. 1-2 (2015).
493. O.B. Jensen, Drone city – power, design and aerial mobility in the age of "smart cities". *Geographica Helvetica, **71***, pp. 67-68 (2016).
494. F. Klauser & S. Pedrozo, Power and space in the drone age: a literature review and politico-geographical research agenda. *Geographica Helvetica, **70***, pp. 285-287 (2015).
495. S. Roche, Geographic information science I: why does a smart city need to be spatially enabled? *Progress in Human Geography, **38***, p. 704 (2014).
496. F. Klauser, T. Paasche & O. Soderstrom, Michel Foucault and the smart city: power dynamics inherent in contemporary governing through code. *Environment and Planning D: Society and Space, **32***, p. 870 (2014).
497. Y. Seto, Application of privacy impact assessment in the smart city. *Electronics & Communications in Japan, **98***, pp. 52-53 (2015).

As critics claim, instead of contributing to the creation of the smart world[498] where everything is globally linked and globally safe, the smart city requires at least a very advanced security technology, as demonstrated by Galdon-Clavell[499]. More often, however, critics of the smart city manifest the need of its deconstruction[500], or the creation of a new concept of the city up to contemporary standards that would adopt other assumptions (or put stress on things differently; for example the MESH city[501] or hackable city[502] proposals come in handy at this point).

It is necessary to strongly underline, however, that in spite of the problems pointed to by critics that without doubt have to be overcome, the smart city is an incredibly interesting vision of the city. On the one hand, as underlined by Sanchez, Elicegui, Cuesta, Munoz and Lanza[503], most interpretations present the smart city as a "new city ecosystem" aimed at increasing the quality of human life, and on the other hand – and most importantly from the perspective of the considerations in this book – the smart city is a vision of a city that carries out a maximally intensive stimulation (through ICT) of people development, i.e. a vision of a city of permanent learning [504] and maximally effective education[505]. Education is not only an element of the smart city[506], but the core of this concept[507]. Batagan[508] even

498. S. Poslad, A. Ma, Z. Wang & H. Mei, Using a smart city IoT to incentivise and target shifts in mobility behavior – is it a piece of pie? *Sensors, **15***, p. 13070 (2015).
499. G. Galdon-Clavell, (Not so) smart cities?: the drivers, impact and risks of surveillance-enabled smart environments. *Science & Public Policy, **40***, p. 722 (2013).
500. I. Calzada & C. Cobo, Unplugging: deconstructing the smart city. *Journal of Urban Technology, **22***, pp. 23-38 (2015).
501. B. Singh, op. cit., p. 50.
502. C. Ampatzidou, M. Bouw, F. van de Klundert, M. de Lange & M. de Waal, *The hackable city: a research manifesto and design toolkit*. Amsterdam: Amsterdam Creative Industries Publishing, p. 9 (2015).
503. L. Sanchez, I. Elicegui, J. Cuesta, L. Munoz & J. Lanza, Integration of utilities infrastructures in a future internet enabled smart city framework. *Sensors, **13***, p. 14439 (2013).
504. E. Tranos & D. Gertner, Smart networked cities?. *Innovation – The European Journal of Social Science Research, **25***, p. 176 (2012); S. Kraus, C. Richter, S. Papagiannidis & S. Durst, op. cit., p. 176.
505. V. Albino, U. Berardi & R.M. Dangelico, Smart cities: definitions, dimensions, performance, and initiatives. *Journal of Urban Technology, **22***, p. 11 (2015).
506. B. Gontar, Z. Gontar & A. Pamula, op. cit., p. 42.
507. L. Batagan, op. cit., p. 83.
508. L. Batagan, Indicators for economic and social development of future smart city. *Journal of Applied Quantitative Methods, **6***, p. 27 (2011).

comes to claim that the smart city term refers itself above all to education, whereas Lombardi, Giordano, Farouh and Yousef[509] that it is not ICT but high-quality education that is the essence of the smart city. Such education is, moreover, supposed to attract people to the smart city, as well as give them competences to develop the smart city concept further. This is why – as explained by Winters[510] – smart cities will permanently grow, both in terms of technological progress and the number of inhabitants. As phrased by Goswami[511], the smart city is thus simply "a centre" for education. And the education refers not only to students of school age, but to all its inhabitants (irrespective of their age), which is why the smart city is also – as shown by Thite[512] – a lifelong learning city. To put it shortly, the smart city is a city based on smart education.

3.2. Smart education – towards learning in CyberParks

Similarly to the smart city, the smart education concept has no commonly accepted definition[513], and it is differently viewed by many researchers (what is more, this notion is sometimes used without any link to its theoretical connotations, as a trendy phrase[514])[515]. Without doubt, however, smart education is a formalized (institutional) version of smart learning described in Chapter 1, and its institutional aspect is supposed to take place in educational systems of the smart city[516]. Smart education is thus planted in the smart

509. P. Lombardi, S. Giordano, H. Farouh & W. Yousef, Modelling the smart city performance. *Innovation: The European Journal of Social Sciences,* ***25***, p. 138 (2012).
510. J.V. Winters, Why are smart cities growing? Who moves and who stays. *Journal of Regional Science,* ***51***, pp. 253-268 (2011).
511. P. Goswami, Matrix for a smart city. *Current Science,* ***109***, p. 246 (2015).
512. M. Thite, Smart cities: implications of urban planning for human resource development. *Human Resource Development International,* ***14***, p. 627 (2011).
513. S.-Y. Kim & M.-R. Kim, Comparison of perception toward the adoption and intention to use smart education between elementary and secondary school teachers. *Turkish Online Journal of Educational Technology – TOJET,* ***12***, p. 64 (2013).
514. K. Glasswell, K. Davis, P. Singh & S. McNaughton, Literacy lessons for Logan learners: a smart education partnerships project. *Curriculum Leadership,* ***31***, pp. 1-4 (2010).
515. J. Jo, J. Park, H. Ji, Y. Yang & H. Lim, A study on factor analysis to support knowledge based decisions for a smart class. *Information Technology & Management,* ***17***, p. 44 (2016).
516. H. Tong & Y. Feng, Smart education and legal governance. *3rd International Conference on Science and Social Research,* pp. 392-394 (2014).

(or at least digital[517]) environment[518] whose saturation with ICT influences the learning strategies both in classroom and at school, as well as away from them[519]. What is more, smart education (as it most often happens in various forms of TEL) is supposed to be a strategy of reducing the costs of formal education[520].

As explained by Jang[521], in the context of smart education the word *smart* is treated as an acronym that stands for:

- **S**elf-directed – in smart education, pupil's role is to manager the process of learning, and teacher's role is only to assist this process.
- **M**otivated – in smart education, the pupils is supposed to be motivated, learn out of their own cognitive curiosity through experience and exploration.
- **A**dapted – in smart education, the course of formal learning is supposed to be flexible, and the school is to cease to be a place for knowledge distribution, and instead become a space that promotes personalized learning.
- **R**esource enriched – in smart education, materials used are supposed to be very diverse and innovative, as well as based on the logics of open access.
- **T**echnology-embedded – in smart education, the latest ICT solutions are to be used which will make it possible to learn anytime and anywhere, but also pupils will be able to learn in any way.

It is thus clear that the smart education idea is a formal manifestation of the assumptions of not only some aspects of smart learning, but of the whole concept of TEL. What is more, as shown by Murai, Hayashi, Stone and Inokuchi[522], smart education refers itself to OL. In smart education, the mobility of

517. P.C. Santana-Mancilla, M.A.M. Echeverria, J.C.R. Santos, J.A.N. Castellanos & A.P.S. Diaz, Towards smart education: ambient intelligence in the Mexican classrooms. *Procedia – – Social and Behavioral Sciences,* ***106***, p. 3142 (2013).
518. J. Jo, K. Park, D. Lee & H. Lim, An integrated teaching and learning assistance system meeting requirements for smart education. *Wireless Personal Communications,* ***79***, pp. 2454-2455 (2014).
519. E. Sykes, New methods of mobile computing: from smartphones to smart education. *TechTrends,* ***58***, p. 27 (2014).
520. R. West, Smart education tax moves. *Journal of Accountancy,* ***194***, pp. 81-85 (2002).
521. S. Jang, op. cit., pp. 74-75.
522. K. Murai, Y. Hayashi, L.C. Stone & S. Inokuchi, Basic evaluation of performance of bridge resource teams involved in on-board smart education: lookout pattern. *Review of the Faculty of Maritime Sciences, Kobe University,* ***3***, pp. 77-83 (2006).

the learning space, a term coined by Kim, Park and Joo[523], is crucial. Moreover, it is assumed here that using ICT in education stimulates explorative learning[524] and learning outside the classroom[525], especially in authentic contexts or close to nature, for example in parks[526]. The idea of technology-enhanced outdoor learning (TEOL) is thus constitutive for the smart education concept.

As explained by Klichowski, Bonanno, Jaskulska, Smaniotto Costa, de Lange and Klauser[527], the completion of the TEOL idea in the smart education reality is supported by two technological pillars. Figure 3.4 shows that these are the digital textbook and cloud computing.

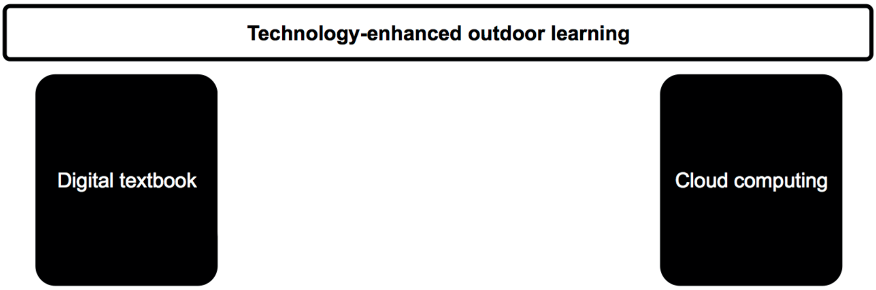


Figure 3.4. Two technological pillars of technology-enhanced outdoor learning. Source: own work based on: M. Klichowski, P. Bonanno, S. Jaskulska, C. Smaniotto Costa, M. de Lange & F. Klauser, CyberParks as a new context for smart education: theoretical background, assumptions, and pre-service teachers' rating. *American Journal of Educational Research, **3***, p. 3 (2015).

The digital textbook is nothing else but a school textbook based on ICT. Its content is presented in an attractive, multimedia way in it; what is more, it is interactive, i.e. it makes it possible to add notes or links to the content

523. S.H. Kim, N.H. Park & K.H. Joo, Effects of flipped classroom based on smart learning on self-directed and collaborative learning. *International Journal of Control & Automation, **7***, p. 72 (2014).
524. A. Ya'acob, N. Nor & H. Azman, Implementation of the Malaysian smart school: an investigation of teaching-learning practices and teacher-student readiness. *Internet Journal of e-Language Learning & Teaching, **2***, p. 17 (2005).
525. D. Igoe, A. Parisi & B. Carter, Smartphones as tools for delivering sun-smart education to students. *Teaching Science: The Journal of the Australian Science Teachers Association, **59***, p. 37 (2013).
526. P.-H. Hung, G.-J. Hwang, Y.-F. Lin, T.-H. Wu & I-H. Su, Seamless connection between learning and assessment-applying progressive learning tasks in mobile ecology inquiry. *Educational Technology & Society, **16***, pp. 195-196 (2013).
527. M. Klichowski, P. Bonanno, S. Jaskulska, C. Smaniotto Costa, M. de Lange & F. Klauser, op. cit., p. 3.

studied etc. The digital textbook can also be used on any mobile device like a smartphone, tablet or laptop[528]. Figure 3.5 shows a sample fragment of such a textbook.

Figure 3.5. A sample fragment of the digital textbook. Source: Persiatj, *Use Case 5 of Digital Textbook* (2008). Under the terms of the Creative Commons Attribution License.

Cloud computing on the other hand is, in simplified terms, something similar to an educational cloud. Such a technology makes it possible to transfer educational materials, in any format, from personal devices to a cloud that can be accessed by all participants of the process of education, anywhere and anytime, without the need to download these materials to the device that they are currently using. This cloud thus makes it possible to learn (and we mean formal learning here!) everywhere, i.e. in all spaces of the smart city, by using any device with access to the Internet[529]. In a meta-analytical study, Gonza-

528. J.-K. Kim, W.-S. Sohn, K. Hur & Y.-S. Lee, Effect of enhancing learning through annotation similarity and recommendation system. *International Journal of Smart Home, 7*, pp. 271-281 (2013); S. Jang, op. cit., pp. 75-77.
529. J.-S. Jeong, M. Kim & K.-H. Yoo, A content oriented smart education system based on cloud computing. *International Journal of Multimedia and Ubiquitous Engineering*, ***8***, pp. 313-325 (2013); J.A. Gonzalez-Martinez, M.L. Bote-Lorenzo, E. Gomez-Sanchez & R. Cano-Parra, Cloud computing and education: a state-of-the-art survey. *Computers & Education*, ***80***, p. 132 (2015); S. Jang, op. cit., pp. 77-78.

lez-Martinez, Bote-Lorenzo, Gomez-Sanchez and Cano-Parra[530] discover many benefits and affordances linked to such a use of cloud computing, such as for example flexible organization of a space for learning and option to learn out of the institution, easy communication and resource sharing, as well as cost savings. However, the authors also point to risks linked to the application of cloud computing in education – it is mainly about threats for the security of private data gathered in a cloud (smart education, as well as the whole smart city, that uses cloud computing is a system based on big data[531])[532]. Figure 3.6 shows the educational application of the cloud computing idea.

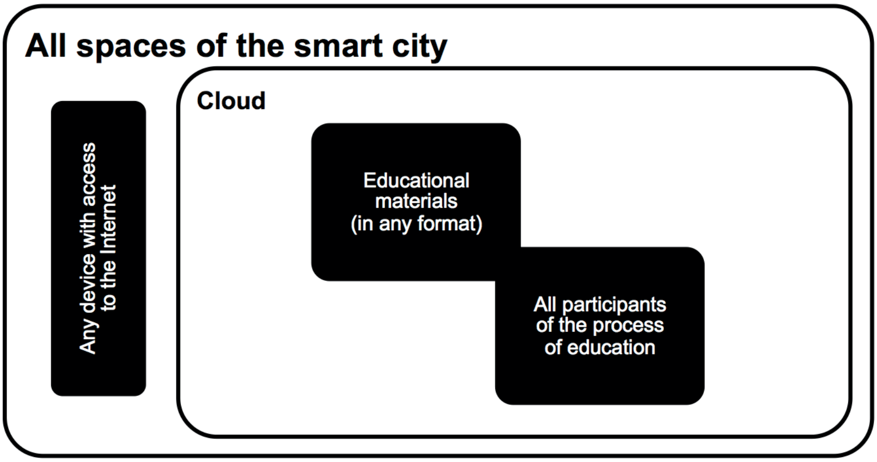


Figure 3.6. The educational application of the cloud computing idea. Source: own work based on: J.-S. Jeong, M. Kim & K.-H. Yoo, A content oriented smart education system based on cloud computing. *International Journal of Multimedia and Ubiquitous Engineering, **8***, p. 317 (2013).

By combining the above theses, it is thus possible to state, just like Kim and Oh[533], that the strategy for the completion of smart education is constituted

530. J.A. Gonzalez-Martinez, M.L. Bote-Lorenzo, E. Gomez-Sanchez & R. Cano-Parra, op. cit., p. 135.
531. J.S. Hwang, S. Lee, Y. Lee & S. Park, A selection method of database system in bigdata environment: a case study from smart education service in Korea. *International Journal of Advances in Soft Computing and its Applications, **7***, p. 18 (2015).
532. J.A. Gonzalez-Martinez, M.L. Bote-Lorenzo, E. Gomez-Sanchez & R. Cano-Parra, op. cit., p. 140.
533. B.H. Kim & S.Y. Oh, A study on the SMART education system based on cloud and n-screen. *Journal of the Korea Academia-Industrial Cooperation Society, **15***, pp. 139-142 (2014).

with the N-screen, concept, i.e. it refers to the vision of learning through any types of screens (i.e. any types of ICT tools, for example smartphones, tablets, laptops, computers, TV sets) connected to an educational cloud that is full of educational resources, and serving as a platform for educational communication. Through the application of the TEOL concept, the smart education leads students equipped with mobile screens (mobile ICT tools), connected to the school cloud, out of educational institutions and into spaces for authentic learning or learning close to nature, especially to city green spaces and parks. In order for the smart education to be effective in places of this sort, these spaces should be equipped with an additional, digital dimension – the parks should be CyberParks[534].

3.3. The CyberParks concept

As observed by Lindholst, Konijnendijk van den Bosch, Kjoller, Sullivan, Kristoffersson, Fors and Nilsson[535], one of the central places in the contemporary global urban planning (not so fascinated with the idea of the west city[536] anymore) is occupied by the question about what should be done for cities to be "good" urban green spaces, and especially "good" parks? As well as – as indicated by Thomas[537] – what should be done for city dwellers to actually use these green spaces or parks (contemporary culture promotes staying indoors in a plethora of ways, for example "many people prefer to stay indoors attracted to wired way of life experiencing virtual reality and/or engage themselves in virtual community rather than being outdoors engaging in a real community"[538])?

534. M. Klichowski & C. Smaniotto Costa, How do pre-service teachers rate ICT opportunity for education? A study in perspective of the SCOT theory. *Culture and Education, **4***, p. 158 (2015); M. Klichowski, P. Bonanno, S. Jaskulska, C. Smaniotto Costa, M. de Lange & F. Klauser, op. cit., pp. 3-5.
535. A.C. Lindholst, C.C. Konijnendijk van den Bosch, C.P. Kjoller, S. Sullivan, A. Kristoffersson, H. Fors & K. Nilsson, Urban green space qualities reframed toward a public value management paradigm: the case of the Nordic Green Space Award. *Urban Forestry & Urban Greening, **17***, p. 166 (2016).
536. T. Kenna, Teaching and learning global urban geography: an international learning-centred approach. *Journal of Geography in Higher Education*, ***41***, p. 1 (2017).
537. S. Thomas, op. cit.
538. T. Duarte, C. Smaniotto Costa, D. Mateus, M. Menezes & A. Bahillo, Pervasive open public spaces – the amalgamation of information and communication technologies into open public spaces. Reflections of the COST Action – TU 1306 CyberParks. In:

As shown by Menezes and Smaniotto Costa[539], one of the ideas for improving and making urban green spaces more attractive is “adding to them a new dimension – the virtual, blurring the boundaries between the physical and digital. Different terms are emerging to refer to this amalgamation, as mediated, hybrid, networked spaces and CyberPark”. Yet, Raiyn[540] adds that “the major goal of using ICT in a Cyber-Park is to promote people to better use the outdoor environment. Modern ICT aims to promote people to move from the virtual life to real life in society. In other words ICT tools aim to free human from prison called virtual life a predominantly sedentary behaviour [...]. ICT can be used to incentive people to use public spaces, to spend more time outdoors”.

Such a solution is quite innovative, because previously “the natural environment and digital domains were seen as distinctly different”[541]. However, the issue has changed in the recent years. As noticed by Duarte, Smaniotto Costa, Mateus, Menezes and Bahillo[542], “the use of digital communication devices in public spaces is already a reality. It is common to see people outdoors using smartphones or tablets for phoning, reading, searching, sending emails, etc”. This applies to all to types of public spaces, also including urban green spaces. What is more, results of numerous studies show that mobile ICT tools can stimulate outdoor physical activity[543], reduce the time spent in front of the screen at home and use the time saved to spend it close to nature[544], enhance healthy lifestyles[545], prevent illnesses that result from a sedentary

O. Marina & A. Armando (Eds.), *Projects for an inclusive city. Social integration through urban growth strategies* (p. 213). Skopje: City of Skopje (2015).

539. M. Menezes & C. Smaniotto Costa, People, public space, digital technology and social practice: an ethnographic approach. In: A. Zammit & T. Kenna (Eds.), *Enhancing Places through Technology. Proceedings from the ICiTy conference* (p. 167). Lisbon: Edicoes Universitarias Lusofonas (2017).
540. J. Raiyn, Modern information and communication technology and their application in CyberParks. *Journal of Multidisciplinary Engineering Science and Technology, **2***, p. 2178 (2015).
541. S. Thomas, op. cit.
542. T. Duarte, C. Smaniotto Costa, D. Mateus, M. Menezes & A. Bahillo, op. cit., p. 213
543. P.M. Hurvitz, A.V. Moudon, B. Kang, B.E. Saelens & G.E. Duncan, Emerging technologies for assessing physical activity behaviors in space and time. *Frontiers in Public Health, **2***, pp. 1-13 (2014).
544. D.R. Lubans, J.J. Smith, G. Skinner & P.J. Morgan, Development and implementation of a smartphone application to promote physical activity and reduce screen-time in adolescent boys. *Frontiers in Public Health, **2***, pp. 1-10 (2014).
545. M. Suchocka, K. Kimic, G. Maksymiuk & N. Kolodynska, Outdoor hotspots as a tool for enhancing healthy lifestyles of ICT users. In: A. Zammit & T. Kenna (Eds.), *Enhancing*

lifestyle[546], and even support the development of fundamental movement skills in children[547]. However, it is not just about using ICT tools outdoors. This new dimension is supposed to allow to create "intelligent environments where sensors and computers are seamlessly embedded to enhance ordinary park activities, places where the landscape itself might respond to people moving through it"[548]. It is thus about equipping the urban green space with some kind of technological infrastructure[549].

As explained by Ioannidis, Smaniotto Costa, Suklje-Erjavec, Menezes and Martinez[550], the history of such outdoor cyber-mediated spaces began with artistic activities where various types of technological objects (sounds, images, lighting etc.) were used to attract city dwellers' attention. Afterwards, this idea was transformed into practical actions, directed at encouraging city dwellers to be active with their own ICT tools in urban green spaces (for example through services like mobile charging or wireless sensor network hotspots). Finally, the continuous growth of the idea of cyberspatial outdoor experience, and as a consequence the more and more intense implementation of ICT into urban green spaces, paved the way to the creation of CyberParks.

Admittedly, the idea of CyberParks was created as early as in 1984 by a team of researchers from Ljubljana (Slovenia), led by Suklje-Erjavec; however, its actual introduction in academic and public discourse took place only at the beginning of the second decade of the 21st century, as a result of the operations by Smaniotto Costa and his co-workers (including Suklje-Erjavec herself)[551]. According to them, the CyberPark is nothing else but a technologically en-

Places through Technology. Proceedings from the ICiTy conference (pp. 153-160). Lisbon: Edicoes Universitarias Lusofonas (2017).

546. M.I. Stuckey, A.M. Kiviniemi & R.J. Petrella, Diabetes and technology for increased activity study: the effects of exercise and technology on heart rate variability and metabolic syndrome risk factors. *Frontiers in Endocrinology, 4*, pp. 1-5 (2013).
547. L.M. Barnett, S. Bangay, S. McKenzie & N.D. Ridgers, Active gaming as a mechanism to promote physical activity and fundamental movement skill in children. *Frontiers in Public Health, 1*, pp. 1-2 (2013).
548. S. Thomas, op. cit.
549. M. Menezes & C. Smaniotto Costa, op. cit., p. 168.
550. K. Ioannidis, C. Smaniotto Costa, I. Suklje-Erjavec, M. Menezes & A.B. Martinez, The lure of CyberPark – synergistic outdoor interactions between public spaces, users and locative technologies. In I. Theona & C. Dimitris (Eds.), *Hybrid city 2015: data to the people* (p. 273). Athens: URIAC (2015).
551. S. Thomas, op. cit.

hanced urban green space[552], thus some kind of a hybrid space, combining a real, nature-based space with technology[553], or – in other words – blended digital/urban green spaces[554]. An example of this can be a park with free Wi-Fi where it is possible to move around using a dedicated application and where various types of interactive devices are located (for example screens that can serve information about the plants or history of this park)[555]. Not every CyberPark, however, has to be a typical urban park. As explained by Smaniotto Costa and Suklje-Erjavec[556], other types of urban green spaces, such as green squares, gardens, greenways, green belts, community and allotment gardens, waterfronts, urban woodlands and urban wilderness (and sometimes even other, less green elements of the open public space) can also become CyberParks. CyberParks are places in the city that in a sense are close to nature[557], where it is possible to use ICT tools and where various ICT solutions encourage to stay and be active, especially when they encourage physical activity in them[558].

Although the CyberParks concept is very young, it has not avoided criticism already. Researchers claim that, similarly to smart cities, CyberParks will be spaces producing big data[559] and potential targets of cyber attacks, which is why they will require special IT protection[560]. By referring himself to Nietzsche and Benjamin's philosophical considerations, Patricio[561] also notices that the combination of two contradictory realities of nature and technology that is

552. K. Ioannidis, C. Smaniotto Costa, I. Suklje-Erjavec, M. Menezes & A.B. Martinez, op. cit., p. 273.
553. T. Duarte, C. Smaniotto Costa, D. Mateus, M. Menezes & A. Bahillo, op. cit., p. 215).
554. C. Smaniotto Costa, M. Menezes & I. Suklje-Erjavec, How can information and communication technologies be used to better understand the way people use public spaces: first reflections of the COST Action CyberParks – TU 1306. In: C.A. Marques (Ed.), *Planeamento cultural urbano em areas metropolitanas* (pp. 1-7). Casal de Cambra: Editora Caleidoscopio (2015).
555. Ibidem.
556. C. Smaniotto Costa & I. Suklje-Erjavec, Information and communication technologies and the public spaces: reflections on exploring a new relationship – first results from COST Action CyberParks TU 1306. *Proceedings of EURO ELECS*, p. 1800 (2015).
557. Ibidem, pp. 1800-1805; C. Smaniotto Costa, M. Menezes & I. Suklje-Erjavec, op. cit., pp. 4-5.
558. K. Ioannidis, C. Smaniotto Costa, I. Suklje-Erjavec, M. Menezes & A.B. Martinez, op. cit., p. 279; C. Smaniotto Costa, M. Menezes & I. Suklje-Erjavec, op. cit., pp. 5-6.
559. J. Raiyn, Introduction to big data management based on agent oriented CyberParks. *Journal of Multidisciplinary Engineering Science and Technology, **2***, pp. 2432-2436 (2015).
560. J. Raiyn, op. cit., pp. 2178-2182.
561. C. Patricio, CyberParks and geo-aesthetics – reading modern technology after Nietzsche. In: A. Zammit & T. Kenna (Eds.), *Enhancing Places through Technology. Proceedings from the ICiTy conference* (pp. 273-276). Lisbon: Edicoes Universitarias Lusofonas (2017).

characteristic of the CyberParks concept results in "imparting" both nature and technology, depriving nature of its full naturalness, and technology of its full technicality. Is it thus possible to learn effectively in CyberParks?

3.3.1. Learning in CyberParks

Kukulska-Hulme and Jones[562] notice that "spaces only make sense when considered in relation to what is made of them, people's behaviours and appropriation of space, therefore learners' activities and the technologies they make use of are the other key elements". This is why researchers agree that natural surroundings, enriched with a technological dimension (of the CyberPark type), form an attractive learning context[563]. As shown in Figure 3.7, this type of hybrid space (blended digital/green spaces) combines the institutional (top-down) and personal (individual) dimension of learning, and not only in the context of the same space and learning matter as is the case in OL, but also of technology as is characteristic of TEL.

It is thus clear that TEOL completed in the smart city (for example partially in CyberParks) is close to the technological reality of a pupil and dynamics of growth of their life space (of the city that they live in), but it also refers to their culture's problems, such as lack of movement and nature. It is thus possible to say that the TEOL idea (as well as learning in CyberParks) fits the pedagogical approach called urban education. According to the definition by Smith, Bradley, Cook and Pratt-Adams[564], it takes into account "the complexities of the urban setting, urban lives and educational contexts in the face of new and emerging social and cultural relationships".

On a side note, it is worth adding that Zimmerman and Land[565] created a kind of design guidelines for TEOL. They notice that in order to maximize

562. A. Kukulska-Hulme & C. Jones, The next generation: design and the infrastructure for learning in a mobile and networked world. In: A.D. Olofsson & J.O. Lindberg (Eds.), *Informed design of educational technologies in higher education: enhanced learning and teaching* (p. 66). Hershey: Information Science Reference (2012).

563. S.M. Land & H.T. Zimmerman, op. cit., p. 230.

564. C. Smith, C. Bradley, J. Cook & S. Pratt-Adams, Designing for active learning: putting learning into context with mobile devices. In: A.D. Olofsson & J.O. Lindberg (Eds.), *Informed design of educational technologies in higher education: enhanced learning and teaching* (p. 329). Hershey: Information Science Reference (2012).

565. H.T. Zimmerman & S.M. Land, Facilitating place-based learning in outdoor informal environments with mobile computers. *TechTrends: Linking Research and Practice to Improve Learning*, ***58***, p. 78 (2014).

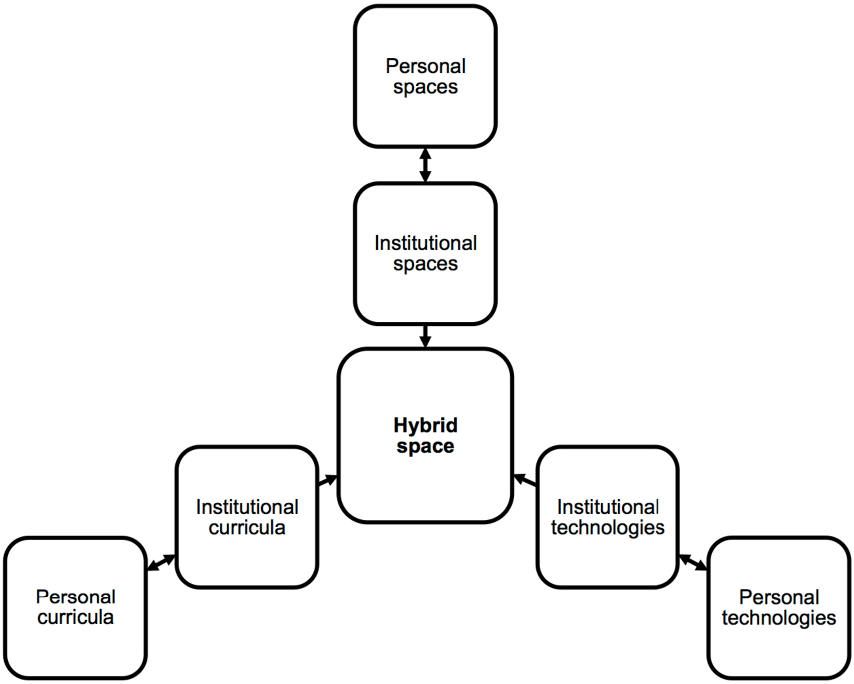


Figure 3.7. Conceptualizing the design for technology-enhanced outdoor learning (learning in hybrid spaces, such as CyberParks). Source: own work based on: A. Kukulska-Hulme & C. Jones, The next generation: design and the infrastructure for learning in a mobile and networked world. In: A.D. Olofsson & J.O. Lindberg (Eds.), *Informed design of educational technologies in higher education: enhanced learning and teaching* (p. 67). Hershey: Information Science Reference (2012).

the effectiveness of this type of learning, it is necessary to take elements of the idea of place-based education into account while designing it, such as:

- "Facilitate participation in disciplinary conversations and practices within personally relevant places.
- Amplify observations to see the disciplinary-relevant aspects of a place.
- Connect local experiences to those of general, disciplinary concerns through exploring new perspectives, representations, conversations, or knowledge artefacts".

What is learning in CyberParks then? To sum up the considerations in this book up to this point, it can be said that learning in CyberParks is a potential element of smart learning, carried out in the form of TEOL. By using CyberParks in formal education, learning in CyberParks becomes additionally an element of smart education, i.e. the concept of formal education in the smart city. Moreover, in Line with the concept of CyberParks themselves, learning in CyberParks is not only supposed to ensure close access to nature to pupils (nature-based learning), but also stimulate them to be physically active (whole-body learning)[566]. It is also recommended for its contents to be linked to some extent and in some sense to the space where it takes place. Are there any examples of how this sort of learning is carried out (not necessarily in CyberParks) in order to illustrate the technological sense of this process?

For instance, Hung, Lin and Hwang[567] describe the use of the Personal Digital Assistant (PDA) and e-library by children to observe nature. In this example, after a preliminary diagnosis of pupils' knowledge, the process of observing selected natural objects begins, accompanied by taking notes (in the form of a text, film, photo, sound etc.) on them via the PDA. Then, once the observation is over, pupils compare their notes with information in the e-library. Perez-Sanagustin, Parra, Verdugo, Garcia-Galleguillos and Nussbaum[568], as well as Lai, Chang, Li, Fan and Wu[569], indicate, however, that QR codes described in Chapter 1 can be an interesting technological TEOL solution. Equipped with smartphones or tablets, pupils walk around a garden and scan QR codes placed all over on different objects (for example, on trees, bushes or monuments), thus receiving to their ICT tools some interesting information about those objects that they can then transform and supplement (for example, by adding a multimedia note). Yet another technological strategy is presented by Pan, Tu and Chien[570]. In their example, a Kinect-laptop-integrated system has been places in some interesting spots in a park. The Kinect system recognizes pupils' movements, and based on that it activates short educational films about a certain place of interest on the laptop (the system uses the so-called Kinect-Activating Film-Playing Device).

As underlined by the previously quoted Perez-Sanagustin, Parra, Verdugo, Garcia-Galleguillos and Nussbaum[571], GPS (short for Geographic Positioning

566. M. Klichowski & C. Patricio, op. cit., p. 224.
567. P.-H. Hung, Y.-F. Lin & G.-J. Hwang, Formative assessment design for PDA integrated ecology observation. *Educational Technology & Society, **13***, pp. 35-38 (2010).
568. M. Perez-Sanagustin, D. Parra, R. Verdugo, G. Garcia-Galleguillos & M. Nussbaum, op. cit., pp. 73-74.
569. H.-C. Lai, C.-Y. Chang, W.-S. Li, Y.-L. Fan & Y.-T. Wu, The implementation of mobile learning in outdoor education: application of QR codes. *British Journal of Educational Technology, **44***, pp. E58-E62 (2013).
570. W.F. Pan, S.-C. Tu & M.-Y. Chien, Feasibility analysis of improving on-campus learning paths via a depth sensor. *Interactive Learning Environments, **22***, pp. 515-517 (2014).
571. M. Perez-Sanagustin, D. Parra, R. Verdugo, G. Garcia-Galleguillos & M. Nussbaum, op. cit., p. 73.

System[572]) continues to be the most frequently and efficiently used technology in this context. Applications (run on a smartphone or tablet) that use GPS to determine where the student is located (or what they have covered, i.e. GPS-tracking[573]) are utilized here, so that they receive information suitable for the place they are currently at (for example, if they are in a park close to an interesting tree species, their smartphone runs an animation that shows its structure)[574]. Ludwig and Jesberg[575] provide an interesting example of how GPS is used in parks. They describe the MathCityMap-project (MCM-project) where a portal and application aimed at learning maths in a park have been created. When walking in a park with their smartphones, pupils are directed to various places in the park through a map displayed in the application, and when they get to a given place, the application provides them with a math task, for example consisting in calculating the capacity of the water tank located next to the park fountain. If pupils find it difficult to solve the task, they use hints in the portal or ask questions to other users (teachers or pupils) via the portal. Furthermore, Schwartz[576] points to the fact that the GPS can also be used to learn local history and geography in the park; the teacher can select suitable waypoints, and pupils visit and explore them, directed by the GPS.

The first dedicated CyberParks application – Way (from *Where are you?*[577]) CyberParks application (WayApp) is also based on the GPS. The WayApp was created within a research programme developed by Deusto Tech-Mobility in Bilbao (Spain)[578] and "composed by a mobile platform and a monitoring web service, continued to evolve into a set of options for customizable settings. On

572. M. Perez-Sanagustin, P.J. Munoz-Merino, C. Alario-Hoyos, X. Soldani & C. Delgado Kloos, Lessons learned from the design of situated learning environments to support collaborative knowledge construction. *Computers & Education, **87***, p. 71 (2015).
573. M.R. Mikkelsen & P. Christensen, Is children's independent mobility really independent? A study of children's mobility combining ethnography and GPS/mobile phone technologies. *Mobilities, **4***, pp. 42-44 (2009).
574. J. Mannheimer Zydney & Z. Warner, Mobile apps for science learning: review of research. *Computers & Education, **94***, p. 7 (2016).
575. M. Ludwig & J. Jesberg, Using mobile technology to provide outdoor modelling tasks – the mathcitymap-project. *Procedia – Social and Behavioral Sciences, **191***, pp. 2778-2780 (2015).
576. J.E. Schwartz, Unlocking thinking through and about GPS. *Children's Technology & Engineering, **20***, pp. 12-13 (2016).
577. A. Bahillo, T. Aguilera, F.J. Alvarez & A. Perallos, WAY: seamless positioning using a smart device. *Wireless Personal Communications, **94***, p. 4 (2017).
578. C. Smaniotto Costa, M. Menezes & D. Mateus, *How would tourists use green spaces? Case studies in Lisbon. Project CyberParks – COST TU 1306*. Lisbon: Edicoes Universitarias Lusofonas, p. 12 (2014).

one hand, it could track the way people use the space, allowing them to get contextual information and to send suggestions or complains. On the other, the web could monitor the way people use the space in real time allowing to visualize people's path filtered by gender, age, occupation, or reason for visiting the space. Moreover, users could not only upload their personal profile but also share media material (images, videos etc.) depicting the content of their individual space-related experiences, while using the application in both online and offline environment"[579]. As noticed by Pierdicca, Malinverni, Khromova, Marcheggiani, Bonanno, Franco and Martinez[580], the WayApp has a large potential in the context of smart learning – both as a strategy for gaining information about a place explored and as a platform for cooperation with other participants of the learning process (for example by exchanging smart data, i.e. data collected by the application linked to multimedia notes created by its users[581]). Additionally, the WayApp can use the strategy of mixed reality learning described in Chapter 1, i.e. allow to learn by expanding real images with a virtual dimension[582]. However, has the effectiveness of such solutions been scientifically proven?

3.3.2. Learning in CyberParks from the perspective of recent studies

As observed by Hung, Hwang, Su and Lin[583] "outdoor teaching is widely recognized as one of the best alternative teaching methods [...]. However, some outdoor teaching approaches are ineffective because students lack expert

579. K. Ioannidis, C. Smaniotto Costa, I. Suklje-Erjavec, M. Menezes & A.B. Martinez, op. cit., p. 274.
580. R. Pierdicca, E.S. Malinverni, A. Khromova, E. Marcheggiani, P. Bonanno, F.J.A. Franco & A.B. Martinez, The integration of an augmented reality module within the Way – Cyberparks App. The case study of Valletta city. In: A. Zammit & T. Kenna (Eds.), *Enhancing Places through Technology. Proceedings from the ICiTy conference* (pp. 63-66). Lisbon: Edicoes Universitarias Lusofonas (2017).
581. P.J. Lister, Evaluating smart city learning. In: A. Zammit & T. Kenna (Eds.), *Enhancing Places through Technology. Proceedings from the ICiTy conference* (pp. 242-243). Lisbon: Edicoes Universitarias Lusofonas (2017).
582. P. Bonanno, A.B. Martinez, R. Pierdicca, E. Marcheggiani, F.J.A. Franco & E.S. Malinverni, A connectivist approach to smart city learning: Valletta city case-study. In: A. Zammit & T. Kenna (Eds.), *Enhancing Places through Technology. Proceedings from the ICiTy conference* (pp. 75-76). Lisbon: Edicoes Universitarias Lusofonas (2017).
583. P.-H. Hung, G.-J. Hwang, I-H. Su & I-H. Lin, A concept-map integrated dynamic assessment system for improving ecology observation competences in mobile learning activities. *Turkish Online Journal of Educational Technology – TOJET, **11***, p. 10 (2012).

guidance and appropriate outdoor learning tools. With the advantages of portability and easy information access, the use of mobile technology is a growing trend in education. Therefore, the application of information technology in outdoor teaching has become an attractive research topic". However, despite the fact that the TEOL is recognized as such an interesting area of scientific exploration (that requires research[584]), it is not penetrated by academics too often. As shown by the meta-analysis conducted by Sung, Chang and Liu[585], only slightly over 15 per cent of educational research is about the broadly understood OL, of which very few studies link OL with TEL, and if at all, then usually in the context of informal learning. Research by Land and Zimmerman[586] can serve as an example here, where the effectiveness of informal learning among kids and their parents was studied with the use of mobile devices in an arboretum.

Furthermore, even if research is conducted where an experimental factor in the form of TEOL is introduced in formal education, most often its effectiveness is examined by collecting opinions of the participants of this experiment (instead of examining its real effects)[587]. For example, the results of a study by Peng and Sollervall[588] consisting in an experimental introduction of TEOL to the strategies of teaching mathematics to primary school students solely show that those pupils demonstrated a positive approach towards this solution.

On the other hand, as noticed by Zhou, Dai, Huang, Sun, Hu, Hu and Ivanovic[589], this type of research should not only measure the behavioural effects of TEOL, but also "consider the dynamic psychological reactions of the learners through the studies of their physiological signals such as EEG, ECG, EDR, respiration, and skin temperature by a wearable device system and assist

584. P.-H. Hung, Y.-F. Lin & G.-J. Hwang, op. cit., p. 33.
585. Y.-T. Sung, K.-E. Chang & T.-C. Liu, The effects of integrating mobile devices with teaching and learning on students' learning performance: a meta-analysis and research synthesis, *Computers & Education, **94***, pp. 257-262 (2016).
586. S.M. Land & H.T. Zimmerman, op. cit., pp. 234-242.
587. Y.-M. Huang & P.-S. Chiu, The effectiveness of the meaningful learning-based evaluation for different achieving students in a ubiquitous learning context. *Computers & Education, **87***, p. 252 (2015).
588. A. Peng & H. Sollervall, Primary school students' spatial orientation strategies in an outdoor learning activity supported by mobile technologies. *International Journal of Education in Mathematics, Science and Technology, **2***, pp. 247-255 (2014).
589. X. Zhou, G. Dai, S. Huang, X. Sun, F. Hu, H. Hu & M. Ivanovic, Cyberpsychological computation on social community of ubiquitous learning. *Computational Intelligence and Neuroscience, **2015***, p. 6 (2015).

in obtaining a more precise psychological assessment of the learners' situations". In short, TEOL, just as is the case with TEL (which has been presented in Chapter 1), requires research in cognitive neuroscience and psychophysiology. However, there is none.

Still, there are the results of some reliable experimental studies where real effects of TEOL completed in a way close to learning in CyberParks were measured. For example, Hsiao, Lin, Feng and Li[590] examined two fifth-grade classes in an elementary school. They randomly selected one class as their control group, and one class as their experimental group. Prior to the experiment, both classes participated in a pre-test on ecological conservation. Then each of them took part in outdoor ecology classes in the same park for four hours. The classes were exactly the same for both groups, yet the learning materials and learning sheet of the control group were printed in paper, and the experimental group used multimedia learning materials on smartphones. After the classes, researchers conducted a post-test on ecological conservation. As shown in Figure 3.8, it turned out that the experimental group scored significantly higher in learning, i.e. generally speaking that TEOL is more effective than traditional OL.

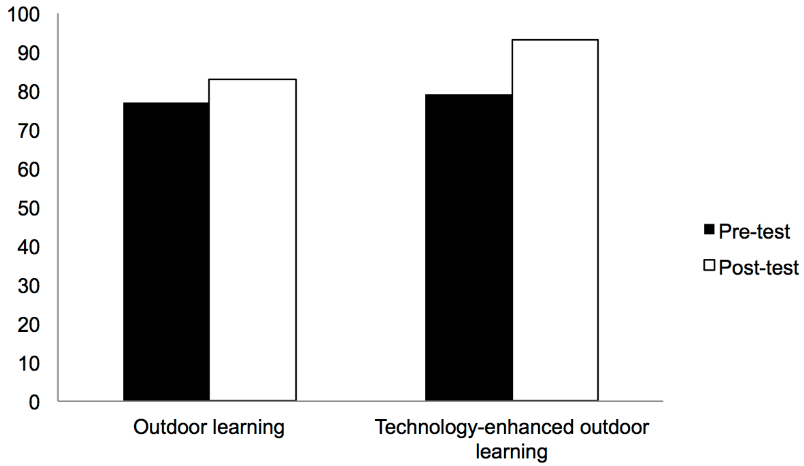


Figure 3.8. An experimental comparison of technology-enhanced outdoor learning with traditional outdoor learning. These outdoor classes were about ecology and were conducted in a park. Source: own work based on: H.-S. Hsiao, C.-C. Lin, R.-T. Feng & K.J. Li, Location based services for outdoor ecological learning system: design and implementation. *Journal of Educational Technology & Society, 13*, p. 105 (2010).

590. H.-S. Hsiao, C.-C. Lin, R.-T. Feng & K.J. Li, Location based services for outdoor ecological learning system: design and implementation. *Journal of Educational Technology & Society,* ***13***, pp. 99-100 (2010).

Similar results showing greater effectiveness of TEOL as compared to traditional OL were also achieved by Huang, Chen and Chou[591], who conducted classes for middle school students in a garden and enriched them with elements of mixed reality learning, as well as Hung, Hwang, Su and Lin[592] who organized a 3-month cycle of outdoor classes for sixth-grade students, with the use of smartphones and digital cameras, and a telescope. Interestingly enough, Su and Cheng[593] research results also show that TEOL not only dominates the traditional OL, but also TEL itself. These researchers compared the results of classes on the same subjects conducted for fourth-graders in the form of TEL and TEOL. It turned out that classes who had their lessons in the form of TEOL scored significantly higher.

All that research is focused on comparing the effectiveness of learning in case of using ICT tools (TEOL) or not using them (OL), or in case of being outdoors (OL) or in class (traditional learning). However, one factor that is key to the idea of CyberParks was not taken into account, i.e. the link between cognitive activity and physical activity. And this link (called the dual-task) can bring about very surprising results, as suggested by results of cognitive neuroscience research.

3.3.3. Learning in CyberParks and the dual-task cost

As observed by Wajda, Motl and Sosnoff[594], traditionally, physical and cognitive activity "have been viewed as unrelated, but there is evidence of cognitive-motor interference". In the recent years, when conducting cognitive neuroscience research, it has been noticed that brain regions related to higher cognitive control are activated while carrying out simple types of physical activity, such as gait[595], so far recognized as automated. As underlined by Woollacott and

591. T.-C. Huang, C.-C. Chen & Y.-W. Chou, Animating eco-education: to see, feel, and discover in an augmented reality-based experiential learning environment. *Computers & Education,* ***96***, pp. 75-80 (2016).
592. P.-H. Hung, G.-J. Hwang, I-H. Su & I-H. Lin, op. cit., pp. 14-16.
593. C.-H. Su & C-H. Cheng, op. cit., pp. 268-286.
594. D.A. Wajda, R.W. Motl & J.J. Sosnoff, Dual task cost of walking is related to fall risk in persons with multiple sclerosis. *Journal of the Neurological Sciences*, ***335***, p. 160 (2013).
595. M. Bakker, F.P. De Lange, R.C. Helmich, R. Scheeringa, B.R. Bloem & I. Toni, Cerebral correlates of motor imagery of normal and precision gait. *NeuroImage,* ***41***, pp. 998-1010 (2008); S. Huda, R. Rodriguez, L. Lastra, M. Warren, M.G. Lacourse, M.J. Cohen & S.C. Cramer, Cortical activation during foot movements. II. Effect of movement rate and side.

Shumway-Cook[596], this suggests that cognitive factors play an important role in controlling activities such as walking, or even that "there are significant attentional requirements for postural control".

What is more, as explained by Yuan, Koppelmans, Reuter-Lorenz, De Dios, Gadd, Wood, Riascos, Kofman, Bloomberg, Mulavara and Seidler[597], it was also observed that while performing cognitive-motor tasks, "performance in one or both tasks typically declines when two tasks are carried out simultaneously". For example, as demonstrated by Al-Yahya, Dawes, Smith, Dennis, Howells and Cockburn[598], when a person is walking, their gait speed drops immediately if they start carrying out some type of cognitive task, such as recalling a shopping list or attending to a conversation. As shown by Nagamatsu, Voss, Neider, Gaspar, Handy, Kramer and Liu-Ambrose[599], probably specific cognitive processes such as attention "collectively ensure our safety during mobility". When a person carries out a cognitive task apart from a motor task, their attention resources aimed at ensuring safe movement are limited[600], thus in order to ensure safety, this person's brain slows the gait down, and yet the risk

Neuroreport, ***19***, pp. 1573-1577 (2008); K. Iseki, T. Hanakawa, J. Shinozaki, M. Nankaku & H. Fukuyama, Neural mechanisms involved in mental imagery and observation of gait. *NeuroImage,* ***41***, pp. 1021-1031 (2008); C. Rosano, H. Aizenstein, J. Brach, A. Longenberger, S. Studenski & A.B. Newman, Special article: gait measures indicate underlying focal gray matter atrophy in the brain of older adults. *Journals of Gerontology Series A-Biological Sciences and Medical Sciences,* ***63***, pp. 1380-1388 (2008); S. Francis, X. Lin, S. Aboushoushah, T.P. White, M. Phillips, R. Bowtell & C.S. Constantinescu, fMRI analysis of active, passive and electrically stimulated ankle dorsiflexion. *NeuroImage,* ***44***, pp. 469-479 (2009); T. Harada, I. Miyai, M. Suzuki & K. Kubota, Gait capacity affects cortical activation patterns related to speed control in the elderly. *Experimental Brain Research,* ***193***, pp. 445-454 (2009).

596. M. Woollacott & A. Shumway-Cook, Attention and the control of posture and gait: a review of an emerging area of research. *Gait & Posture,* ***16***, pp. 1, 13 (2002).
597. P. Yuan, V. Koppelmans, P.A. Reuter-Lorenz, Y.E. De Dios, NE. Gadd, S.J. Wood, R. Riascos, I.S. Kofman, J.J. Bloomberg, A.P. Mulavara & R.D. Seidler, Increased brain activation for dual tasking with 70-days head-down bed rest. *Frontiers in Systems Neuroscience,* ***10***, p. 2 (2016).
598. E. Al-Yahya, H. Dawes, L. Smith, A. Dennis, K. Howells & J. Cockburn, Cognitive motor interference while walking: a systematic review and meta-analysis. *Neuroscience & Biobehavioral Reviews,* ***35***, pp. 716-717 (2011).
599. L.S. Nagamatsu, M. Voss, M.B. Neider, J.G. Gaspar, T.C. Handy, A.F. Kramer & T.Y. Liu-Ambrose, Increased cognitive load leads to impaired mobility decisions in seniors at risk for falls. *Psychology and Aging,* ***26***, p. 253 (2011).
600. M. Bonato, K. Priftis, C. Spironelli, M. Lisi, C. Umilta & M. Zorzi, Dual-tasks induce awareness deficits for the contralesional hemispace. *Frontiers in Human Neuroscience,* ***129***, p. 1 (2012).

of a fall is very high then[601]. It can also work the other way round – dual-task walking may not only reduce the gait speed, but also cognitive performance, especially if it is impossible to substantially decrease physical activity[602]. This effect – illustrated in Figure 3.9A – is called the dual-task cost[603].

As cognitive processes weaken when the human body grows old, results of many studies show that the older the person is the bigger the reduction of gait speed (and also stride length) during dual-task walking[604]. In addition, this effect increases the difficulty and task type, and more precisely which brain area a given cognitive task is processed (see Figure 3.9B)[605]. On the other hand, the level of reduction of cognitive performance is influenced above all by the intensity of physical activity, i.e. for example by the speed of gait (see Figure 3.9C)[606].

It is worth adding that because the dual-task cost has been correlated with attention, dual-tasks, such as verbal fluency, calculating or smartphone use during walking – as indicated by Takeuchi, Mori, Suzukamo, Tanaka and Izumi[607] – activate the prefrontal cortex (see Figure 3.10), which plays a role in executive functions such as attention. Thus, some people, for example those who have suffered a stroke in this brain region, are unable to carry out cognitive-motor tasks[608]. According to Suzuki, Hiraishi, Sugawara and Higashi[609], suitable training that requires carrying out various types of dual-tasks can, however, bring this function back to some extent.

As stated by the previously mentioned Takeuchi, Mori, Suzukamo, Tanaka and Izumi[610], one of the most popular forms of dual-task nowadays is the

601. K. Pothier, N. Benguigui, R. Kulpa & C. Chavoix, Multiple object tracking while walking: similarities and differences between young, young-old, and old-old adults. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, ***70***, pp. 840-841 (2014).
602. N. Takeuchi, T. Mori, Y. Suzukamo, N. Tanaka & S.-I. Izumi, Parallel processing of cognitive and physical demands in left and right prefrontal cortices during smartphone use while walking. *BMC Neuroscience,* ***17***, p. 2 (2016).
603. P. Yuan, V. Koppelmans, P.A. Reuter-Lorenz, Y.E. De Dios, NE. Gadd, S.J. Wood, R. Riascos, I.S. Kofman, J.J. Bloomberg, A.P. Mulavara & R.D. Seidler, op. cit., p. 2.
604. K. Pothier, N. Benguigui, R. Kulpa & C. Chavoix, op. cit., pp. 844-845; E. Al-Yahya, H. Dawes, L. Smith, A. Dennis, K. Howells & J. Cockburn, op. cit., pp. 720-723.
605. K. Pothier, N. Benguigui, R. Kulpa & C. Chavoix, op. cit., pp. 844-846; E. Al-Yahya, H. Dawes, L. Smith, A. Dennis, K. Howells & J. Cockburn, op. cit., p. 725.
606. K. Pothier, N. Benguigui, R. Kulpa & C. Chavoix, op. cit., pp. 844-846.
607. N. Takeuchi, T. Mori, Y. Suzukamo, N. Tanaka & S.-I. Izumi, op. cit., pp. 2-9.
608. T. Suzuki, M. Hiraishi, K. Sugawara & T. Higashi, Development of a smartphone application to measure reaction times during walking. *Gait & Posture*, ***50***, pp. 217-218 (2016).
609. Ibidem, p. 221.
610. N. Takeuchi, T. Mori, Y. Suzukamo, N. Tanaka & S.-I. Izumi, op. cit., pp. 1-2.

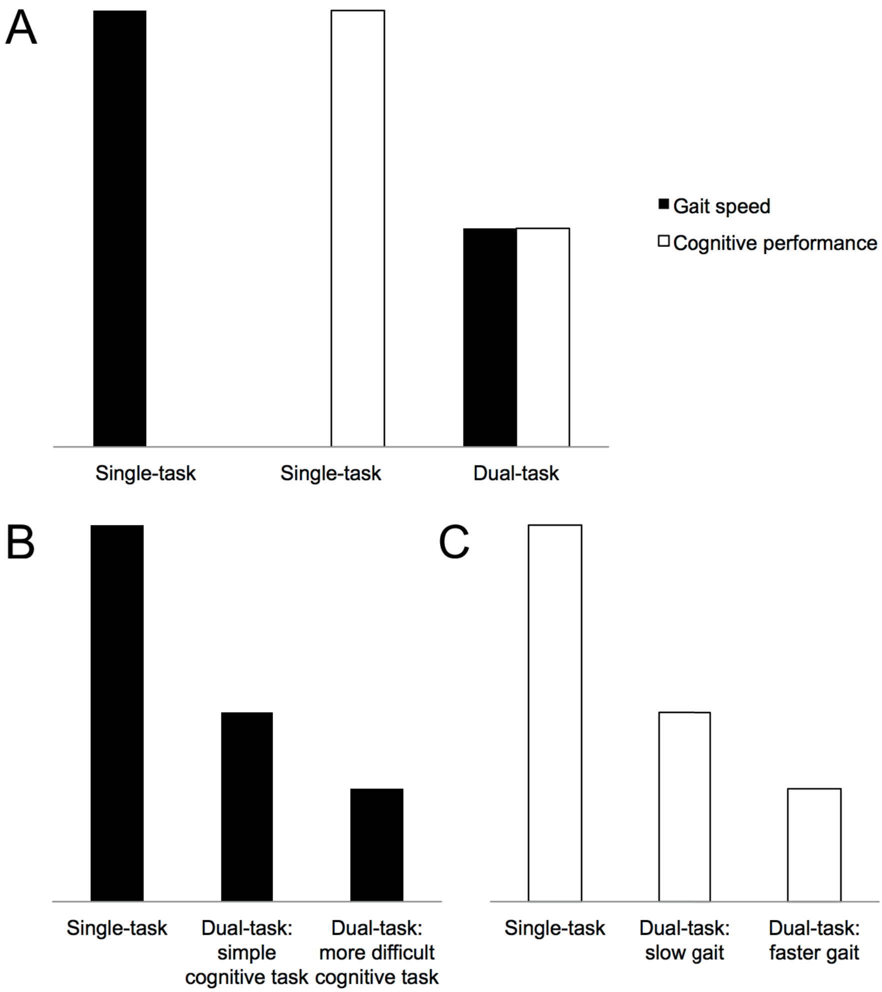


Figure 3.9. Cost of dual-task walking. **(A)** Dual-task walking reduced gait speed and/or cognitive performance. **(B)** The more difficult a cognitive task is, the more the gait is reduced. **(C)** The higher the gait is, the more the cognitive processes are weakened. Source: own work based on: E. Al-Yahya, H. Dawes, L. Smith, A. Dennis, K. Howells & J. Cockburn, Cognitive motor interference while walking: a systematic review and meta-analysis. *Neuroscience & Biobehavioral Reviews,* ***35***, pp. 724-726 (2011); K. Pothier, N. Benguigui, R. Kulpa & C. Chavoix, Multiple object tracking while walking: similarities and differences between young, young-old, and old-old adults. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, ***70***, pp. 843-845 (2014).

smartphone use while walking, which "requires an appropriate allocation of cognitive and physical resources to each task. Overload of central resources is associated with an inability to allocate attention appropriately between simultaneously performed cognitive and physical tasks. Therefore, smartphone

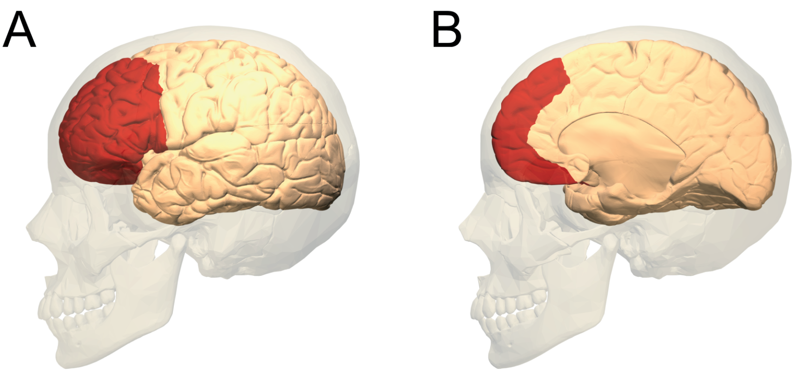


Figure 3.10. Prefrontal cortex. (A) Lateral view. (B) Medial view. Source: Center for Life Science. Under the terms of the Creative Commons Attribution License.

use while walking is becoming a public concern with respect to the risk of collisions and falls, due to cognitive-motor interference". Indeed, both studies (unfortunately carried out in laboratory conditions and not in real-life situations[611]) as medical statistics (that show an increase in the number of accidents involving a passer-by using a smartphone) confirm that the smartphone use while walking does increase the risk of falls[612]. This problem is so widespread that special smartphone applications (the WalkSafe App for example) have even started to be produced to help smartphone users avoid falling down or having an accident while walking[613].

Nevertheless, there are no results of research that would analyse to what extent the smartphone use while walking weakens cognitive processes. Yet, if it is weakened considerably, not only does the idea of learning in CyberParks as a combination of cognitive activity – carried out via smartphones (or tablets or other mobile ICT tools) – with physical activity (for example walking around a park) refer to a dangerous activity (moving around with a smartphone increases the risk of falling down or having an accident), but also to one that is cognitively ineffective. Can learning be effective when a student's cognitive performance is decreased? Thus, before the idea of learning in CyberParks

611. L.S. Nagamatsu, M. Voss, M.B. Neider, J.G. Gaspar, T.C. Handy, A.F. Kramer & T.Y. Liu-Ambrose, op. cit., p. 254.
612. M. Yamada, T. Aoyama, K. Okamoto, K. Nagai, B. Tanaka & T. Takemura, Using a smartphone while walking: a measure of dual-tasking ability as a falls risk assessment tool. *Age and Ageing*, ***40***, pp. 516-519 (2011).
613. A. Campbell & T. Choudhury, From smart to cognitive phones. *IEEE Pervasive Computing*, ***11***, p. 9 (2012).

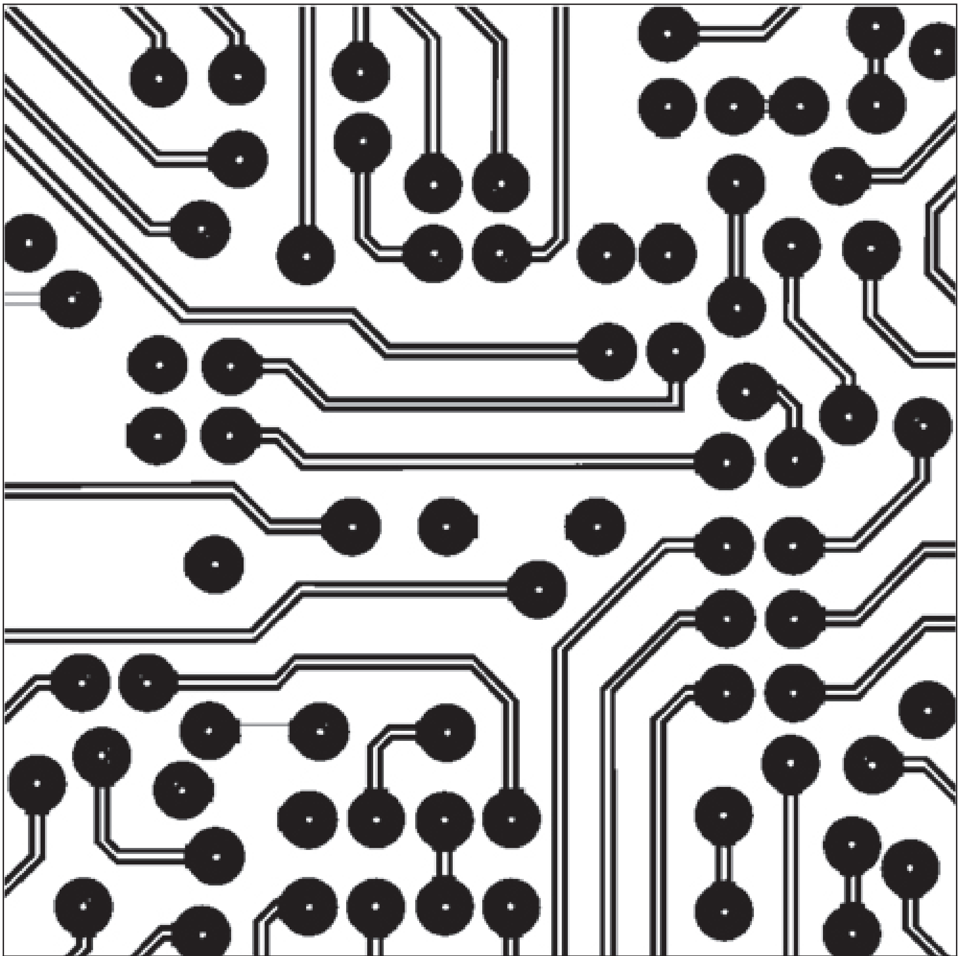
starts to be used in practice, it is necessary to carry out research that would help solve this problem in some way. Part two of this book provides evidence from such research.

Conclusions

This chapter showed that there is a trend in developing modern cities to rebuild them so that they become spaces for permanent and maximally effective learning. Such learning is to be based on the TEOL concept, i.e. it is to take place close to nature (for example in parks), via mobile ICT tools. However, in order for those tools to work effectively in such spaces, those spaces have to be equipped with a digital dimension. Thus, parks have to be transformed into CyberParks. Learning in CyberParks is not only supposed to ensure students close access to nature, but also stimulate them to be physically active. None of the research carried out so far has confirmed, however, whether this cognitive-motor interference is beneficial for the students. What is more, the dual-task cost concept suggests that it can expose students to the danger of a fall or accident while carrying out various activities in CyberParks, as well as it can weaken their cognitive abilities, depriving the idea of learning in CyberParks of its actual sense. The second part of the book will present the results of first research that verified whether learning in CyberParks based on dual-tasks indeed weakens the effectiveness of cognitive processes.

To sum up this part of the book, it has to be underlined that approaches radically critical of TEOL which stress it that OL should be completely free from ICT are also created at present. Such approaches show nature as an alternative to the noise of the city and technological entrapment[614]. However, these critics refer to the TEOL completed in the form of camps or trips out of the city. As an alternative to TEL carried out in the classroom, TEOL does not seem to have many opponents. To paraphrase Oliver's[615] words, in CyberParks, the ICT do not substitute any aspect of nature; they simply make it possible for students, imprisoned for many hours in a school classroom and separated from nature, to come closer to it.

614. Y.T. Uhls, M. Michikyan, J. Morris, D. Garcia, G.W. Small, E. Zgourou & P.M. Greenfield, Five days at outdoor education camp without screens improves preteen skills with nonverbal emotion cues. *Computers in Human Behavior,* ***39***, pp. 387-392 (2014).
615. E. Oliver, Theological education with the help of technology. *HTS Teologiese Studies,* ***70***, p. 5 (2014).



PART II

Learning in CyberParks – an empirical study

CHAPTER 4

Learning in CyberParks and the dual-task cost: experiment under natural conditions

4.1. Methods

In line with the methodological suggestions presented in the first part of the book, the study took the form of an experiment under natural conditions, conducted with the use of cognitive neuroscience tools. The experiment was thus carried out in a real park and both the behavioural effects of learning as well as what happens in the brain during learning were measured as part of it.

The study obtained a positive opinion from the TUD COST Action TU1306 Core Group and was carried out in accordance with the principles of the Helsinki 2013 Declaration.

4.1.1. Participants

Twenty healthy volunteers (16 women, age: 20-21, mean = 20.3, *SD* = 0.5) took part in experiment. These were thus subjects whose ageing processes that might enhance the dual-task cost have not started yet. Each participant expressed their understanding and written consent for the experiment to be conducted. All participants had normal or corrected-to-normal visual acuity. All individuals declared themselves as right-handed, which was confirmed by the results of the revised version of the Edinburgh Handedness Inventory[616]: *Laterality Quotient* = 95.2, *SD* = 15.2, *Laterality Score* = 63.7, *SD* = 11.2. This is important, because the participants carried out the task with one hand on a smartphone with a 3.5-inch screen. Poor sight or left-handedness might thus affect the results.

616. M. Dragovic, Towards an improved measure of the Edinburgh Handedness Inventory: a one-factor congeneric measurement model using confirmatory factor analysis. *Laterality*, **9**, pp. 411-419 (2004).

4.1.2. Procedure and equipment

The experiment was conducted in a park on the university campus. There is Wi-Fi in this park. A special space was marked in the park where a bench was located. The bench was next to a tree and in front of it there was another tree within a distance of 20 metres. A tape was placed at the height of 120 cm on each tree and linked the trees together. After standing up from the bench, it was thus possible to have a walk of 40 metres by strolling along the tape and returning at its end. Figure 4.1 presents a scheme of how the space was organised.

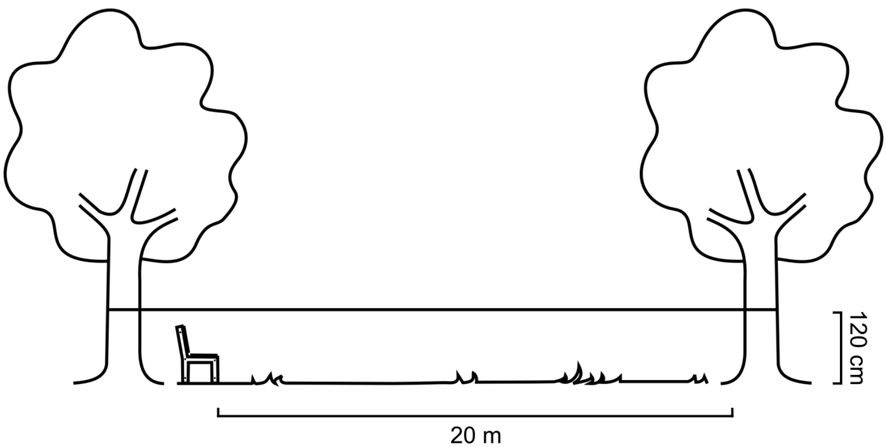


Figure 4.1. Organizing the space in an experiment under natural conditions. In a Wi-Fi equipped park, a bench was placed in a way that made it possible to stand up from it, walk 20 metres ahead and then walk back. The route of the walk was marked with a tape hanging between trees and fixed at the height of 120 cm. Source: own work.

Sitting on the bench or walking along the tape, the participants carried out two tasks on a smartphone. Both tasks were based on classic cognitive neuroscience paradigms used in studying the process of learning. These were: **Sternberg task:** paradigm aimed at examining the effectiveness of memorization. The Sternberg task consists in showing the participant, one by one, a few (not more than seven, as the human working memory can store the maximum of seven objects) stimuli (words, numbers, pictures etc.), and then showing the participants one stimulus and asking them to decide if this stimulus was among those previously presented[617]. In the current experiment, via a smart-

617. A.M. Owen, K.M. McMillan, A.R. Laird & E. Bullmore, N-back working memory paradigm: a meta-analysis of normative functional neuroimaging studies. *Human Brain Mapping*, ***25***, pp. 46-59 (2005); S. Wang, J. Gwizdka & W.A. Chaovalitwongse, Using

phone application created especially for the needs of this study (the application was created in the TypeScript 2.2.0 [the Apache License] programming language, with the use of two frameworks: Angular 4.0.0 [the MIT License] and RxJS 5.1.0 [the Apache License]; Internet access is thus necessary in order to be able to use the app), the participants were shown seven pictures presenting tools. Each picture was displayed for 217 ms (this target duration leads to the required response accuracy[618]). Before each picture appeared, a black cross was displayed for 1000 ms in the middle of the screen space where the pictures were displayed. The participants were instructed in advance that it is a point of fixation and that they were supposed to direct their gaze at it when it was displayed. After seven pictures were displayed, the screen was masked for 1000 ms in order to eliminate the afterimage effect. The mask was followed by a picture and two buttons: "Yes" and "No". By tapping the right button, the participant was supposed to take a decision on whether the picture presented had been displayed among the seven previously displayed ones. The participants carried out the task eight times. Each block contained a different combination of specially prepared pictures of twenty different tools (before the experiment, the participants were shown printouts of the pictures with the names of the tools). Ten tools were positioned in a normal orientation, five in the right-handed orientation, and five in the left-handed orientation (see Appendix B). It was thus impossible for the participants to guess the orientation of the tool. The participants carried out the tasks by turns, either by sitting on the bench (single-task) or walking (dual-task). In order to eliminate the sequence effect, ten of them started from sitting and ten of them started from walking. As a result, even-numbered blocks were carried out while sitting (single-task) by half of the participants, and while walking (dual-task) by the other half of the participants; the case was the same with odd-numbered

wireless EEG signals to assess memory workload in the n-back task. *IEEE Transactions on Human-Machine Systems*, ***46***, pp. 424-435 (2016); N. Tomita, S. Imai, Y. Kanayama, I. Kawashima & H. Kumano, Use of multichannel near infrared spectroscopy to study relationships between brain regions and neurocognitive tasks of selective/divided attention and 2-back working memory. *Perceptual and Motor Skills*, ***124***, pp. 703-720 (2017).

618. N.A. McNair & I.M. Harris, Disentangling the contributions of grasp and action representations in the recognition of manipulable objects. *Experimental Brain Research*, ***220***, p. 74 (2012); M. Krefta, B. Michalowski, J. Kowalczyk & G. Kroliczak, Co-lateralized bilingual mechanisms for reading in single and dual language contexts: evidence from visual half-field processing of action words in proficient bilinguals. *Frontiers in Psychology*, ***6***, p. 3 (2015); M. Klichowski & G. Kroliczak, Numbers and functional lateralization: a visual half-field and dichotic listening study in proficient bilinguals. *Neuropsychologia*, ***100***, p. 95 (2017).

blocks. In each four blocks carried out while sitting (single-task), and in each four blocks carried out while walking (dual-task), there were two tasks where “Yes” should be tapped, and two where the correct answer was “No” (see Appendix C: Part 1). The application registered the answers. Figure 4.2 depicts the trial structure and timing in this task.

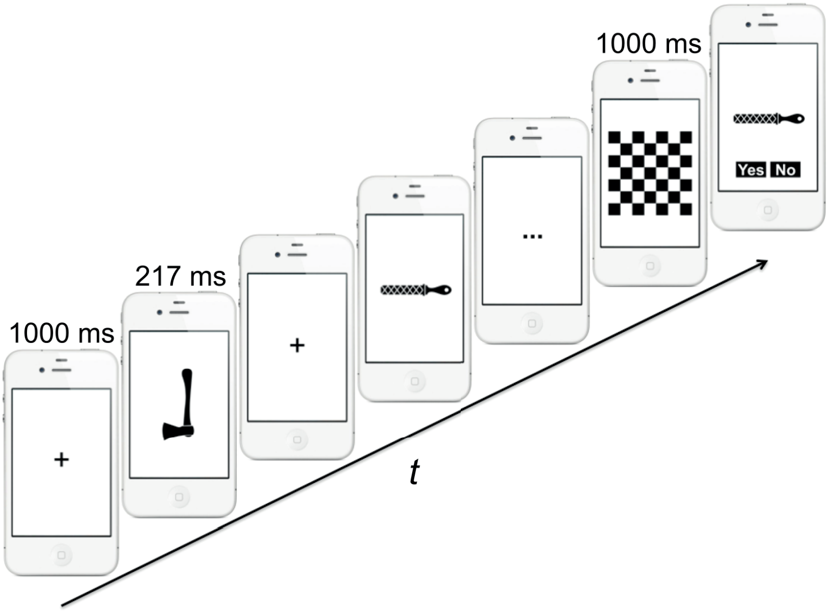


Figure 4.2. The trial structure and timing in Sternberg tasks. A point of fixation was displayed on the smartphone screen for 1000 ms. Then, a picture of a tool was displayed for 217 ms. After seven pictures, a mask was displayed for 1000 ms, and then a picture and two buttons. The participant had unlimited time to tap the selected button. After tapping it, a screen for choosing another block was displayed. A film showing how the application works can be viewed at: cyberparks.amu.edu.pl/book. Source: own work.

Two-back task: paradigm aimed at examining the effectiveness of processing information while memorizing. The two-back task consists in showing several stimuli, one by one (words, numbers, pictures etc.). Every now and then, a picture is repeated. The participant’s task is to react (for example, tap a button) when the picture currently displayed was also displayed exactly two pictures back (thus the name: two-back). The task can also be carried out in other variants, which is why the paradigm is also called the n-back task. When examining children, a simplified version, i.e. one-back, is often used. Due to the fact that there are so many stimuli in the task that the working memory cannot store them all, not only does the participant have to memorize them, but they also have to manipulate them by eliminating those already unnecessary from their working memory (in case of the two-back task, these are the stimuli that were shown more than two sequences before)[619]. In the current experiment, via a smartphone application created especially for the needs of this study (similarly to the previous one, this application was created in the TypeScript 2.2.0 [the Apache License] programming language, with the use of two frameworks: Angular 4.0.0 [the MIT License] and RxJS 5.1.0 [the Apache License]; Internet access is thus necessary in order to be able to use the app), the participants were shown twenty-five pictures presenting tools (it was the same set of pictures as used in Sternberg tasks, see Appendix B). Each picture was displayed for 217 ms (this target duration leads to the required response accuracy[620]). Before each picture appeared, a black cross was displayed for 2500 ms in the middle of the screen space where the pictures were displayed. The participants were instructed in advance that it is a point of fixation and that they were supposed to direct their gaze at it when it is displayed. The participants carried out the task four times. Each block contained a different combination of tools. The participants carried out the tasks by turns, either by sitting on the bench (single-task), or walking (dual-task). In order to eliminate the sequence effect, ten of them started from sitting (single-task) and ten of them started from walking (dual-task). As a result, even-numbered blocks were carried out while sitting (single-task) by half of the participants, and while walking (dual-task) by the other half of the participants; the case was the same with odd-numbered blocks. Each block contained five instances of repeating a picture two sequences further. They appeared in each block at a different moment though (see Appendix C: Part 2). When a picture was repeated in this way, the participant was supposed to tap the screen anywhere. The application registered both the correct and incorrect taps, as well as measured the reaction time (in ms). Figure 4.3 depicts the trial structure and timing in this task.

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619. K. Oberauer, Removing irrelevant information from working memory: a cognitive aging study with the modified Sternberg task. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, ***27***, pp. 948-957 (2001); B. McElree, Working memory and focal attention. *Journal of Experimental Psychology: Learning, Memory and Cognition,* ***27***, pp. 817-835 (2001); C. Klein, L.D. Hernandez, T. Koenig, M. Kottlow, S. Elmer & L. Jancke, The influence of pre-stimulus EEG activity on reaction time during a verbal Sternberg task is related to musical expertise. *Brain Topography*, ***29***, pp. 67-81 (2016); R.O. Konecky, M.A. Smith & C.R. Olson, Monkey prefrontal neurons during Sternberg task performance: full contents of working memory or most recent item?. *Journal of Neurophysiology*, ***117***, pp. 2269-2281 (2017).
620. N.A. McNair & I.M. Harris, op. cit., p. 74; M. Krefta, B. Michalowski, J. Kowalczyk & G. Kroliczak, op. cit., p. 3 (2015); M. Klichowski & G. Kroliczak, op. cit., p. 95 (2017).

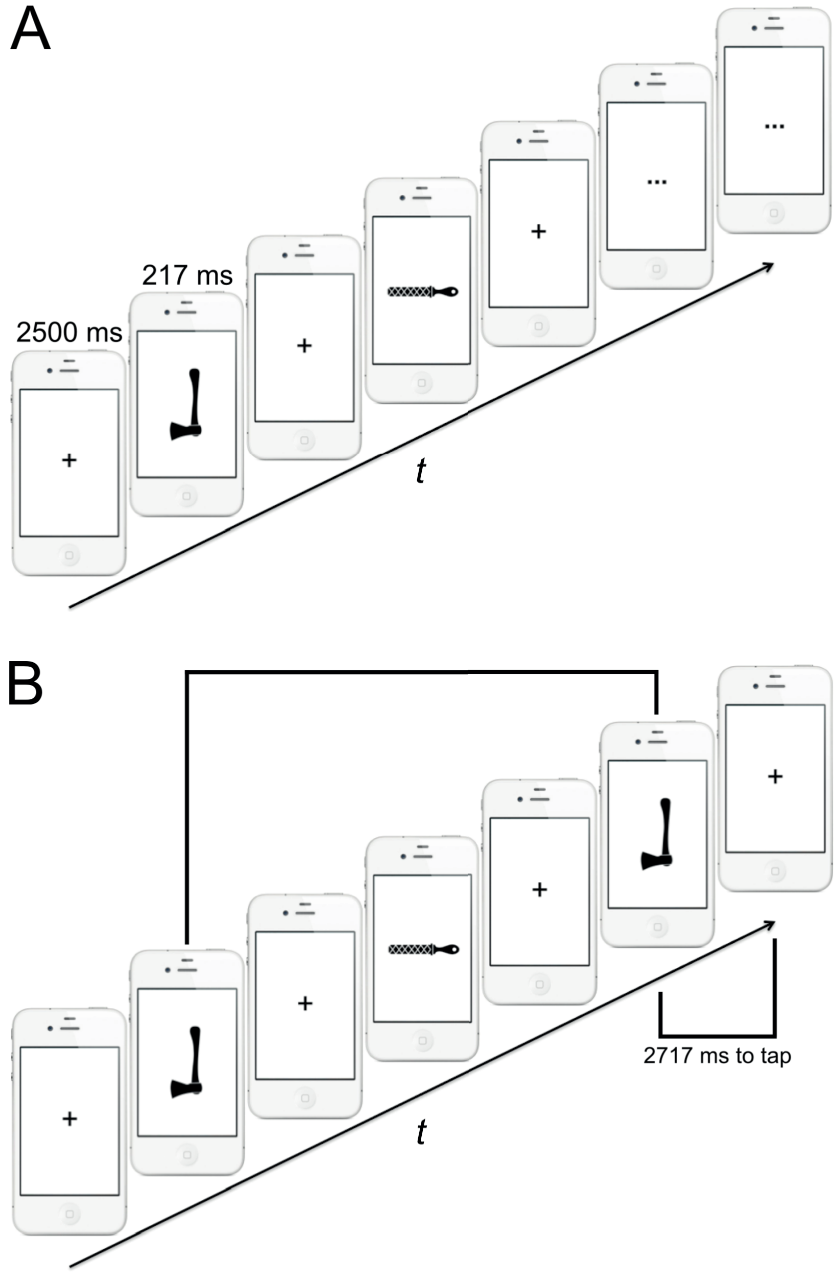


Figure 4.3. The trial structure and timing in two-back tasks. **(A)** A point of fixation was displayed on the smartphone screen for 2500 ms. Then, a picture of a tool was displayed for 217 ms. **(B)** The participant had 2717 ms to tap. After twenty-five pictures, a screen for choosing another block was displayed. A film showing how the application works can be viewed at: cyberparks.amu.edu.pl/book. Source: own work.

The participants carried out the tasks on the iPhone 4s (Apple) with a 3.5-inch screen. They had the MindWave Mobile EEG (NeuroSky) fixed to their heads. The data from the MindWave Mobile EEG was registered via the NeuroSky Recorder 1.0.9 for iOS (NeuroSky) software with the use of the iPhone 6s Plus (Apple). The devices communicated via Bluetooth. The data was also automatically sent to Dropbox. To analyse it, a 13-inch MacBook Pro (Apple) was used, and to visualize it, a 21.5-inch iMac (Apple) was used. Additionally, the Speedometer 3.0 for iOS (Tim O's Studios) application measured their gait (in km/h).

MindWave Mobile EEG is a device belonging to a group of most modern tools used for mobile monitoring of various parameters of the human body[621]. MindWave Mobile EEG is a type of an EEG sensor, i.e. it is used to monitor the parameters (waves) of the human brain[622]. Similar mobile EEG sensors include: Miniature Wireless Acquisition Systems with Quick-20 Dry EEGHeadset (Cognionics), 72-Channel Dry EEG Headset (Cognionics), Multi-Position Dry EEG Headband (Multiposition Dry EEG Headband), EPOC and Insight wireless EEG acquisition systems (Emotiv), Nautiluswireless EEG acquisition system (g.tec), ENOBIO 8 wireless EEG system (Neuroelectrics) and wireless EEG sensor headset (Advanced Brain Monitoring)[623]. However, not only does MindWave Mobile EEG measure the raw signal and power spectrum (alpha, beta, delta, gamma, theta), but it also measures the attention level (mainly based on the beta wave: >14 Hz; this algorithm indicates the intensity of mental focus or focus on a cognitive task; the value ranges from 0 to 100) and meditation level (mainly based on the alpha wave: 8-14 Hz; that algorithm indicates, on the other hand, the level of mental calmness or relaxation; the value also ranges from 0 to 100)[624]. MindWave Mobile EEG makes it thus possible to measure parameters that are significant in research into the dual-task cost. What is more, MindWave Mobile EEG utilizes a single electrode placed on the

621. M.A. Serhani, M. El Menshawy & A. Benharref, SME2EM: Smart mobile end-to-end monitoring architecture for life-long diseases. *Computers in Biology and Medicine*, ***68***, pp. 140-141 (2016).
622. J.C.Y. Sun & K.P.C. Yeh, The effects of attention monitoring with EEG biofeedback on university students' attention and self-efficacy: the case of anti-phishing instructional materials. *Computers & Education*, ***106***, p. 76 (2017).
623. J. Minguillon, M.A. Lopez-Gordo & F. Pelayo, Trends in EEG-BCI for daily-life: requirements for artifact removal. *Biomedical Signal Processing and Control*, ***31***, p. 410 (2017).
624. W. Salabun, Processing and spectral analysis of the raw EEG signal from the MindWave. *Przeglad Elektrotechniczny*, ***90***, p. 169 (2014).

Fp1 position which is elementary for EEG research (see Figure 4.4)[625], i.e. the Brodmann area 10 (BA10). In turn, BA10 is part of the prefrontal cortex[626], i.e. an area that is key to the dual-task as demonstrated in Chapter 3. Furthermore, Fp1 refers to BA10 in the left hemisphere, which supports the use of pictures of tools in the study; tools, as well as their linguistic or graphic symbols, are represented in the left hemisphere[627]. Of course, by receiving signal from Fp1, we do not just collect data from BA10, although such a location of the electrode seems to be very justified in the study conducted. The reference electrode is, in turn, on the ear clip (A1 position, see Figure 4.4)[628].

It is worth adding that even though mobile EEG measuring is still a novelty in scientific research[629], MindWave Mobile EEG is a tool recognized as reliable[630], and as demonstrated by Johnstone, Blackman and Bruggemann[631], measurements carried out with MindWave Mobile EEG significantly correlate with those carried out by stationary EEG systems, for example NuAmps (Compumedics Neuroscan). What is interesting, MindWave Mobile EEG is also

625. M. Abo-Zahhad, S.M. Ahmed & S.N. Abbas, A new multi-level approach to EEG based human authentication using eye blinking. *Pattern Recognition Letters*, ***82***, pp. 217-218 (2016).
626. S. Bludau, S.B. Eickhoff, H. Mohlberg, S. Caspers, A.R. Laird, P.T. Fox, A. Schleicher, K. Zilles & K. Amunts, Cytoarchitecture, probability maps and functions of the human frontal pole. *NeuroImage*, ***93***, p. 260 (2014).
627. D. Tranel, D. Kemmerer, R. Adolphs, H. Damasio & A.R. Damasio, Neural correlates of conceptual knowledge for actions. *Cognitive Neuropsychology*, ***20***, pp. 409-432 (2003); C. Garofeanu, G. Kroliczak, M.A. Goodale & G.K. Humphrey, Naming and grasping common objects: A priming study. *Experimental Brain Research,* ***159***, pp. 55-64 (2004); H. Helon & G. Kroliczak, The effects of visual half-field priming on the categorization of familiar intransitive gestures, tool use pantomimes, and meaningless hand movements. *Frontiers in Psychology,* ***5***, pp. 1-11 (2014); G. Kroliczak & S.H. Frey, A common network in the left cerebral hemisphere represents planning of tool use pantomimes and familiar intransitive gestures at the hand-independent level. *Cerebral Cortex,* ***19***, pp. 2396-2410 (2009); B. Michalowski & G. Kroliczak, Sinistrals are rarely "right": evidence from tool-affordance processing in visual half-field paradigms. *Frontiers in Human Neuroscience,* ***9***, pp. 1-13 (2015).
628. M. Abo-Zahhad, S.M. Ahmed & S.N. Abbas, op. cit., pp. 217-218.
629. M.G. Bleichner & S. Debener, Concealed, unobtrusive ear-centered EEG acquisition: cEEGrids for transparent EEG. *Frontiers in Human Neuroscience*, ***11***, p. 2 (2017).
630. K.S. Hemington & J.N. Reynolds, Electroencephalographic correlates of working memory deficits in children with Fetal Alcohol Spectrum Disorder using a single-electrode pair recording device. *Clinical Neurophysiology*, ***125***, p. 2367 (2014).
631. S.J. Johnstone, R. Blackman & J.M. Bruggemann, EEG from a single-channel dry-sensor recording device. *Clinical EEG and Neuroscience,* ***43***, pp. 112-120 (2012).

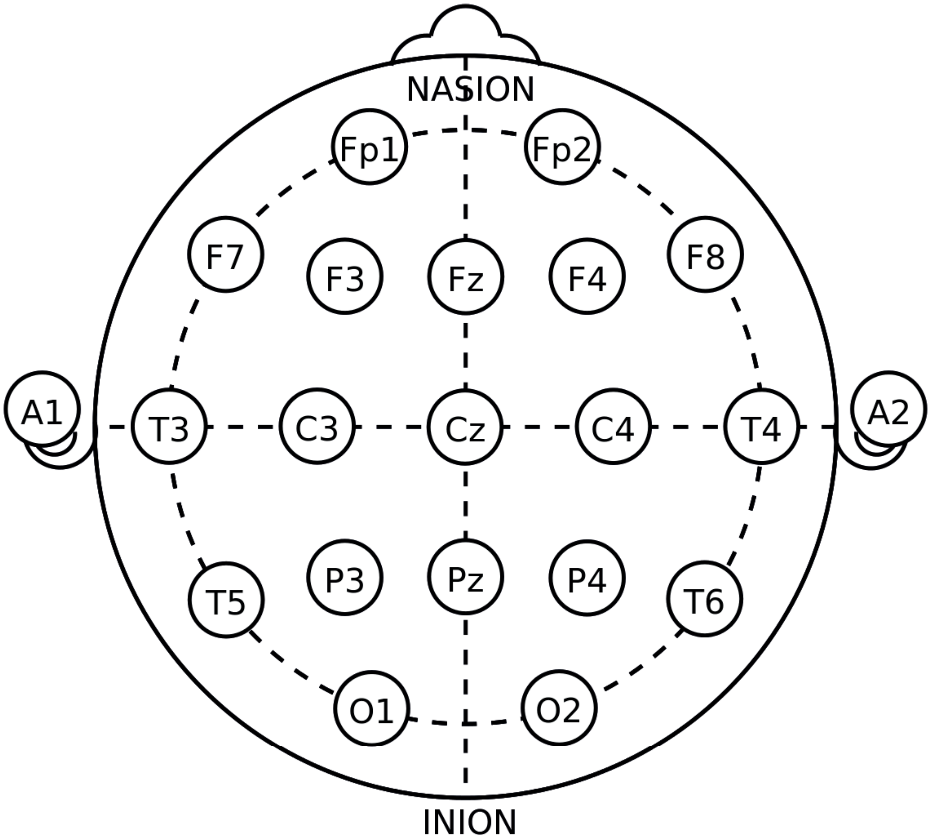


Figure 4.4. A diagram of electrode positioning in EEG research (max. 20 electrodes). By using MindWave Mobile EEG, the electrode is placed in the Fp1 position, whereas the reference electrode in the A1 position. Source: public domain; title: *Electrode locations of International 10-20 system for EEG (electroencephalography) recording*; author: トマトン 124.

used as a brain-computer interface (for example, a fully paralysed person can steer their wheelchair[632] via MindWave Mobile EEG)[633]. Figure 4.5 presents the device design.

632. P.D. Girase & M.P. Deshmukh, Mindwave device wheelchair control. *International Journal of Science and Research, **5***, pp. 2172-2176 (2016).

633. V.R. Varada, D. Moolchandani & A. Rohit, Measuring and processing the brains EEG signals with visual feedback for human machine interface. *International Journal of Scientific & Engineering Research*, ***4***, pp. 1-4 (2013); D. Lacko, J. Vleugels, E. Fransen, T. Huysmans, G. De Bruyne, M.M. Van Hulle, J. Sijbers & S. Verwulgen, Ergonomic design of an EEG headset using 3D anthropometry. *Applied Ergonomics*, ***58***, p. 129 (2017); M. Marchesi, E. Farella, B. Ricco & A. Guidazzoli, MOBIE: a movie brain interactive editor. *SIGGRAPH Asia 2011 Emerging Technologies*, ***11***, p. 16 (2011).

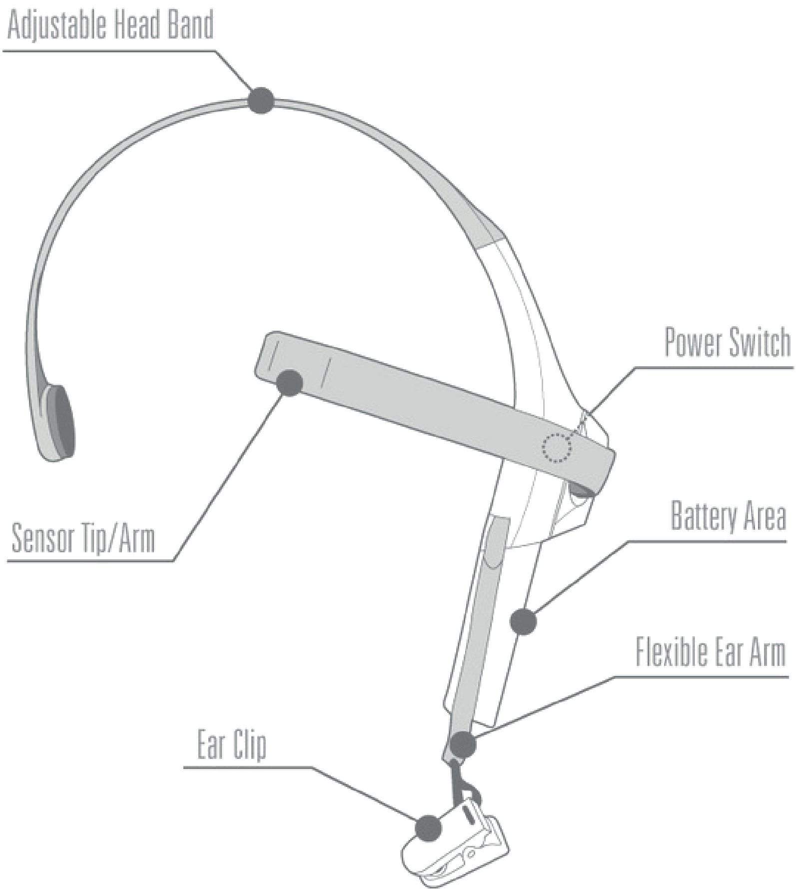


Figure 4.5. MindWave Mobile EEG design. MindWave Mobile EEG utilizes a single electrode placed on the forehead, over the left eye (Fp1 position). The reference electrode is on the clip fixed to the left ear (A1 position). The device is powered with a battery, and the data registered is sent via Bluetooth. Source: neurosky.com.

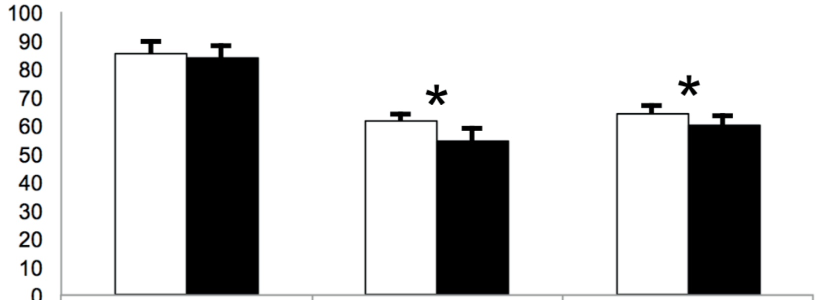
4.1.3. Data analyses

All results are expressed as means. The Student's *t*-test (for dependent samples) or Wilcoxon's *Z*-test were used to compare (continuous) variables. The Kolmogorov-Smirnov test for normality was used to determine the appropriate statistical test (parametric or nonparametric). Finally, correlational analyses were used to investigate whether or not the dynamics of cognitive parameters both for single- and dual-tasks share any common profiles. The adopted level of significance was $\alpha = 0.05$. All statistical analyses were carried out using IBM SPSS Statistics 24.0.

4.2. Results

4.2.1. Sternberg tasks

The dual-task cost was not observed in the context of accuracy (ACC) when carrying out Sternberg tasks (yet, the gait was always visibly slowed down and was of approximately 2.0 km/h, i.e. it was about 1.0-2.0 km/h slower than the average speed of a slow walk). Figure 4.6 shows that the average ACC for single-tasks is 85.0%, and it is not significantly higher than for dual-tasks, for which it is only 1.2% less, i.e. 83.8% ($Z = -0.2$, $p > 0.05$). However, the average attention level is significantly higher for single-tasks, as compared to dual-tasks. And so, it is 61.6 for single-tasks, and only 54.4 for dual-tasks (the difference between means = 7.2, $SE = 3.0$, $t = 2.4$, $p < 0.05$). The situation is the same with the meditation level. For single-tasks it is 64.1, and for dual-tasks it is only 60.1 (the difference between means = 4.0, $SE = 1.8$, $t = 2.2$, $p < 0.05$).



	Accuracy (%)	Attention	Meditation
□ Single-tasks	85	61.6	64.1
■ Dual-tasks	83.8	54.4	60.1

Figure 4.6. Results of the experiment under natural conditions: Sternberg tasks. The dual-task cost was not observed in the context of accuracy. Yet, the effect is visible in case of the attention level and meditation level. Only significant results are indicated here. Asterisks indicate significant *p*-values: $^*p < 0.05$. Error bars depict standard errors of the means. Source: own work.

Figure 4.7A visualizes the dynamics of attention while carrying out Sternberg tasks, i.e. how the attention level changes in time. There were no significant correlations between its profiles ($p > 0.05$). It is also clearly visible that during dual-tasks the dynamics of attention does not reflect the dynamics of the cognitive task, as is the case in single-tasks (here, attention increases when a stimulus to remember appears, and the attention level for each stimulus is similar). Figure 4.7B visualizes the dynamics of meditation. There were also no significant correlations between profiles ($p > 0.05$) and it can be observed that starting a dual-task

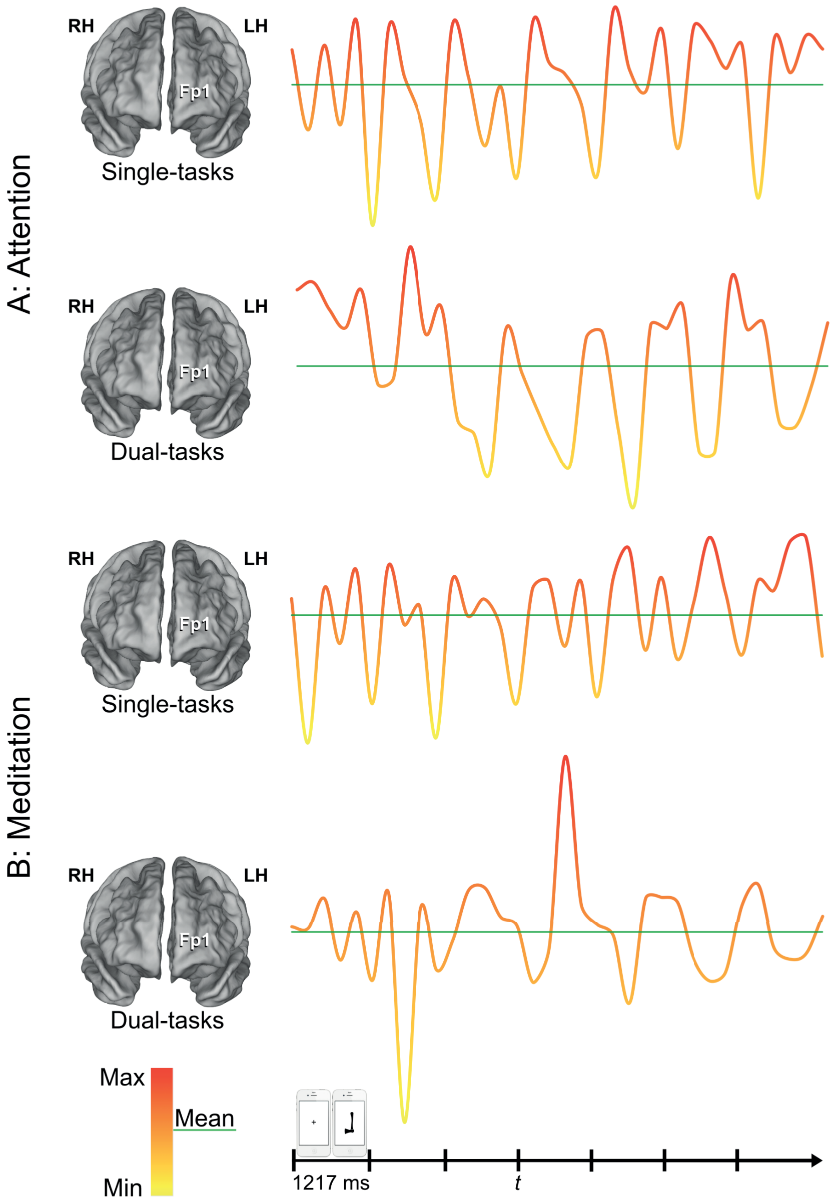


Figure 4.7. The dynamics of attention and meditation at Sternberg tasks (experiment under natural conditions). **(A)** The dual-task cost was observed in the context of the attention level variability in time, in the sense that during dual-tasks the dynamics of attention does not reflect the dynamics of the cognitive task. In single-tasks, the attention increases regularly, every time there is a stimulus to remember. **(B)** The dual-task cost was also observed in the context of the meditation level variability in time. Starting a dual-task causes a lot of stress which accompanies the whole task. During single tasks, the stress level is low and decreases as one gets used to the task. LH – left hemisphere, RH – right hemisphere. Source: own work.

(first step while simultaneously learning the stimuli) causes a lot of stress and the level of tension is not systematically decreased while carrying out the task, as is the case on single-tasks (here, the participant in a way gets used to the task).

4.2.2. Two-back tasks

In case of two-back tasks, no dual-task cost was observed in the context of most of the parameters analysed (the gait, however, was visibly slowed down – – it was approximately 2.0 km/h). Figure 4.8A shows that the average ACC for single-tasks is 83.0%, and is not significantly different from the ACC for dual-tasks where it is 87.5% ($Z = -1.2$, $p > 0.05$). The same is the case for the attention level and meditation level. The former is 53.4 for single-tasks, and 50.4 ($t = 1.2$, $p > 0.05$) for dual-tasks; on the other hand, the latter is 57.6 for single-tasks, and 56.1 ($t = 1.0$, $p > 0.05$) for dual-tasks. In case of the attention level and meditation level, however, there is a visible trend that reflects the logics of the dual-task cost; these values are always lower for dual-tasks (attention level: the difference between means = 3.0, $SE = 2.4$; meditation level: the difference between means = 1.5, $SE = 1.5$).

The dual-task cost was not observed in the context of an average reaction-time for correct answers (RT) or for the average number of incorrect answers, either. As Figure 4.8B shows, the RT is 928 ms for single-tasks, 907 ms ($t = 0.7$, $p > 0.05$) for dual-tasks. Figure 4.8C shows, however, that the participants practically gave no wrong answers, irrespective of whether the tasks were single or dual. In two single-tasks, they tapped incorrectly 0.1 times on average, and 0.4 times in two dual-tasks ($Z = -1.3$, $p > 0.05$), which means that most of them did not get anything wrong at all.

Figure 4.9 visualizes the dynamics of attention and meditation while carrying out two-back tasks, i.e. how their levels change in time. Although there were significant correlations between profiles of attention ($p < 0.05$), Figure 4.9A shows clearly that the dynamics of attention in single-tasks is not the same as the dynamics of attention in dual-tasks. This potential trend ($p = 0.02$) refers to slightly longer periods of lack of concentration during dual-tasks and to the fact that the dynamics of attention reflects the dynamics of the cognitive task during dual-tasks worse than during single-tasks. Figure 4.9B shows that the case is not similar as far as the dynamics of meditation goes: there were no significant correlations between profiles ($p > 0.05$). The profile for single-tasks is different from that of dual-tasks, and these differences refer to slightly longer and stronger periods of stress during dual-tasks.

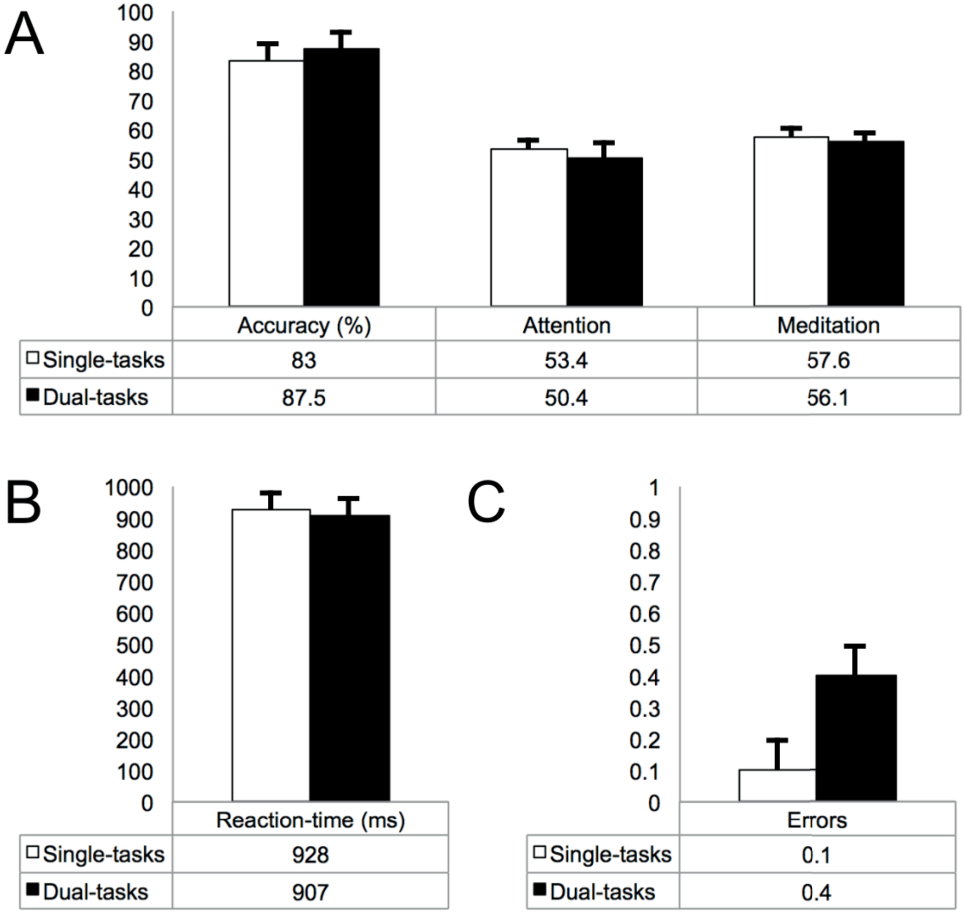


Figure 4.8. Results of the experiment under natural conditions: two-back tasks. (**A**) No dual-task cost was observed in the context of accuracy, attention level or meditation level. (**B**) It was not observed in the context of the average reaction time for correct answers (**C**) or in the context of the average number of incorrect answers, either. Error bars depict standard errors of the means. Source: own work.

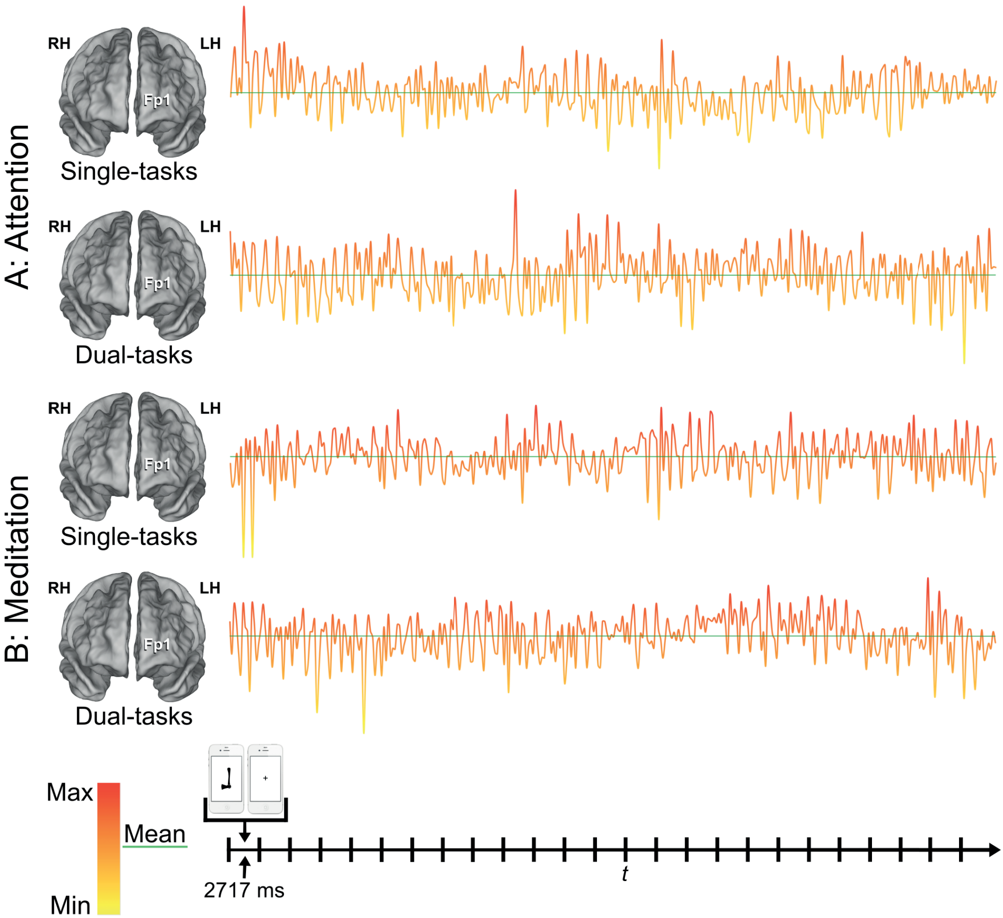


Figure 4.9. The dynamics of attention and meditation during two-back tasks (experiment under natural conditions). (A) No dual-task cost was observed in the context of the attention level variability in time, and a potential trend refers to slightly longer periods of lack of concentration. **(B)** The effect was observed for the meditation level variability in time. The differences refer to slightly longer and stronger periods of stress. LH – left hemisphere, RH – – right hemisphere. Source: own work.

CHAPTER 5

Learning in CyberParks and the dual-task cost: laboratory experiment

5.1. Methods

In order to exclude the influence of variables other than the experimental one (for example, the weather or level of noise in the park) on the results gathered in the experiment under natural conditions (Experiment 1), a similar experiment was conducted in laboratory conditions (Experiment 2).

Similarly to Experiment 1, this experiment obtained a positive opinion from the TUD COST Action TU1306 Core Group and was carried out in accordance with the principles of the Helsinki 2013 Declaration.

5.1.1. Participants

Twenty healthy volunteers (16 women, age: 20-25, mean = 20.5, *SD* = 1.2) took part in this experiment. Similarly to Experiment 1, these were people whose ageing processes that might enhance the dual-task cost have not started yet. Each participant also expressed their understanding and written consent for Experiment 2 to be conducted. All participants had normal or corrected-to-normal visual acuity. All individuals declared themselves as right-handed, which was confirmed by the results of the revised version of the Edinburgh Handedness Inventory[634]: *Laterality Quotient* = 95.7, *SD* = 10.5, *Laterality Score* = 61.0, *SD* = 9.3. As already indicated in Chapter 4, this is important, because the participants carried out the task with one hand on a smartphone with a 3.5-inch screen (poor sight or left-handedness might thus affect the results).

634. M. Dragovic, op. cit., pp. 411-419.

5.1.2. Procedure and equipment

Exactly the same procedure and the same equipment as in Experiment 1 described in Chapter 4 were used in this experiment. However, instead of sitting on a bench in a park, the participants were sitting in a laboratory in a special armchair that had a RD-1 Rotor for Lower Limb Exercise (Meden-Inmed) fixed to it. This type of rotors (also called ergometer pedal exercisers) are used in neurorehabilitation, and aimed at simulating walking with no risk of falling[635]. During the experiment, then, instead of walking along a tape in the park (as in Experiment 1), the participants simulated walking on the rotor. The rotor was also fixed with a speed counter DC4 S (b'Twin). Before the experiment, the participants looked at the speed counter and learnt to keep a rhythm characteristic of a normal, slow walk (3.0-4.0 km/h). Figure 5.1 presents a scheme of how the space was organised.

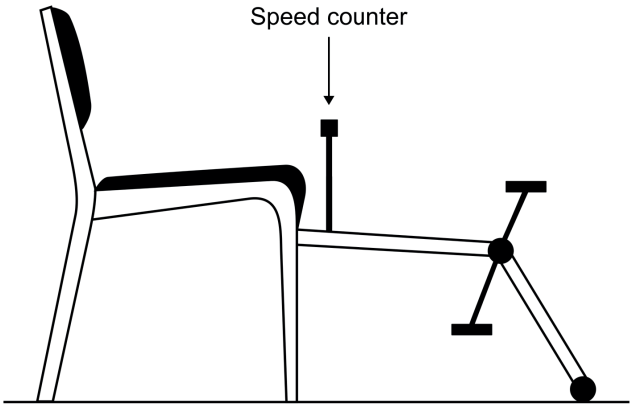


Figure 5.1. Organizing the space in a laboratory experiment. A special armchair equipped with a rotor aimed at simulating walking was placed in a Wi-Fi equipped laboratory. The rotor was equipped with a speed counter that made it possible to learn the right rhythm of a simulated walk. Source: own work.

5.1.3. Data analyses

All results are expressed as means. Exactly the same data analyses as in Experiment 1 described in Chapter 4 were used in this experiment. The adopted level of significance was also $\alpha = 0.05$ and all statistical analyses were carried out using IBM SPSS Statistics 24.0.

635. T. Fujiwara, M. Liu & N. Chino, Effect of pedaling exercise on the hemiplegic lower limb. *American Journal of Physical Medicine & Rehabilitation,* ***82***, pp. 357-363 (2003).

5.2. Results

5.2.1. Sternberg tasks

Similarly to Experiment 1, no dual-task cost was observed in the context of the ACC of carrying out Sternberg tasks. Figure 5.2 shows that the average ACC for single-tasks is 78.8%, and it is not significantly higher than for dual-tasks where it is 2.6% less, i.e. 76.2% ($Z = -0.7$, $p > 0.05$). The average meditation level is (as in Experiment 1) significantly higher for single-tasks, as compared to dual-tasks. And so, for single-tasks it is 65.6, and for dual-tasks only 59.6 (the difference between means = 6.0, $SE = 2.2$, $t = 2.6$, $p < 0.05$). However, differently from Experiment 1, the average attention level for single-tasks is not significantly different from the attention level for dual-tasks. Although it is 63.9 for single-tasks, and only 59.9 for dual-tasks (the difference between means = 4.0, $SE = 3.1$), this difference is not significant ($t = 1.3$, $p > 0.05$). Still, it can be considered as a sort of a trend reflecting the logics of the dual-task cost (worse results in dual-tasks).

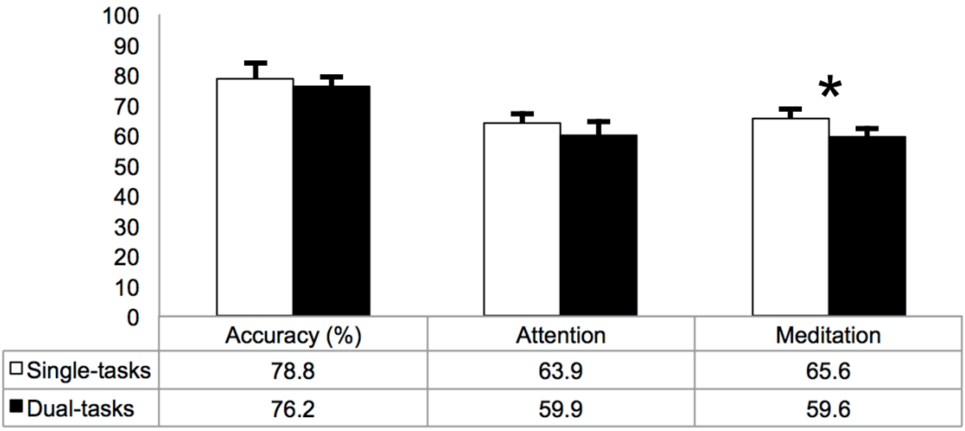


Figure 5.2. Results of the laboratory experiment: Sternberg tasks. No dual-task cost was observed in the context of accuracy or attention level (although a certain trend is visible here). Yet, the effect is visible in case of the meditation level. Only significant results are indicated here. Asterisks indicate significant *p*-values: $^*p < 0.05$. Error bars depict standard errors of the means. Source: own work.

Figure 5.3A visualizes the dynamics of attention while carrying out Sternberg tasks, i.e. how the attention level changes in time. The dynamics of attention in single-tasks is not very similar to the dynamics of attention in dual-tasks, and at the same time there were no significant correlations between

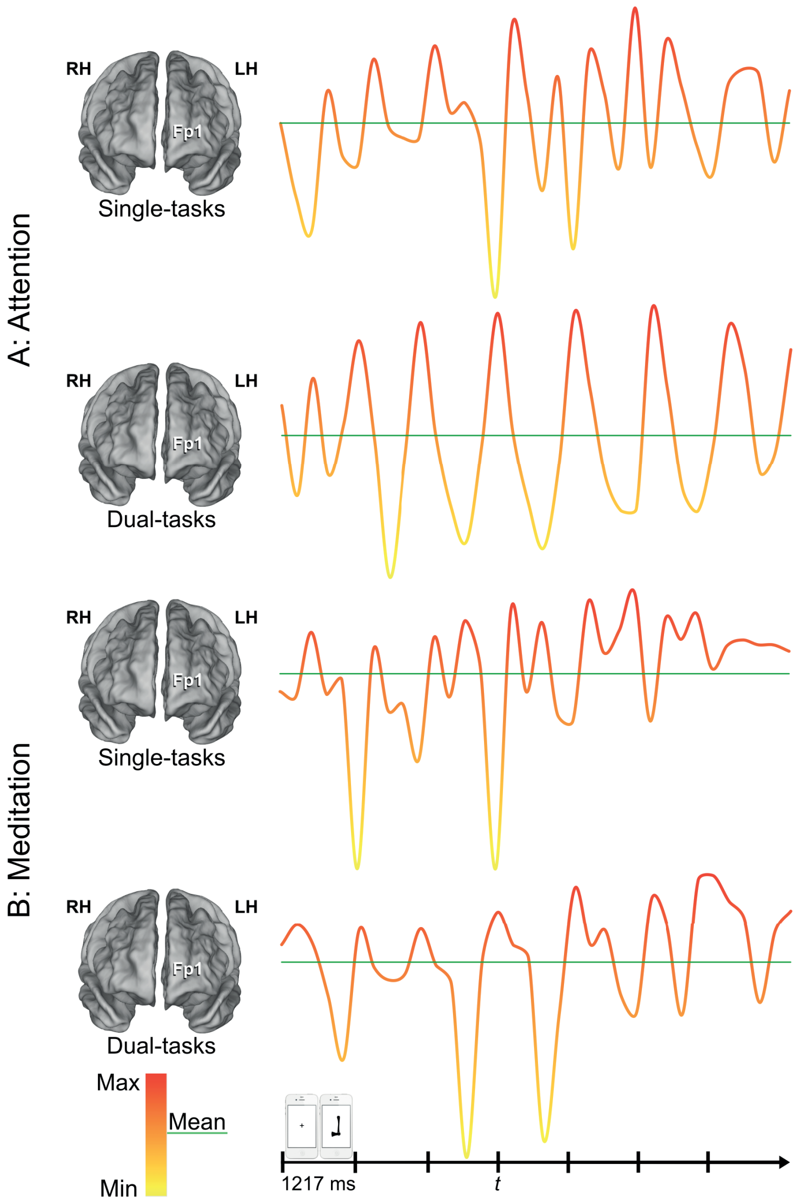


Figure 5.3. The dynamics of attention and meditation during Sternberg tasks (laboratory experiment). (A) The dual-task cost was observed in the context of the attention level variability in time, such as a certain direction is visible linked to the more frequent and longer periods of lack of concentration **(B)** The dual-task cost was also observed in the context of the meditation level variability in time. During single-tasks, the level of stress is low and decreases as one gets used to the task, whereas during dual-tasks the stress is higher, occurs more frequently and lasts longer, and its decrease in time is lower. LH – left hemisphere, RH – right hemisphere. Source: own work.

its profiles ($p > 0.05$). Thus, it is possible to observe a certain direction indicating a longer lack of concentration in dual-tasks. The case is not different when it comes to the dynamics of meditation: there were also no significant correlations between profiles ($p > 0.05$). As Figure 5.3B shows, more frequent and longer periods of stress during dual-tasks can be noticed very clearly. In case of single-tasks, the stress is generally lower, as well as it diminishes and shortens systematically as the task is carried out.

5.2.2. Two-back tasks

As in Experiment 1, no dual-task cost was observed in the context of most of the parameters analysed in case of two-back tasks. Figure 5.4A shows that the average ACC for single-tasks is 86.5%, and it is not significantly different from the ACC for dual-tasks where it is 83.0% ($Z = -1.2$, $p > 0.05$). The case is similar with the attention level. For single-tasks it is 48.3, and for dual-tasks it is 47.7 ($t = 1.3$, $p > 0.05$). In both cases, however, a trend is visible that reflects the logics of the dual-task cost: these values are always lower than for dual-tasks (ACC: the difference between means = 3.5%, $SE = 2.8\%$; attention level: the difference between means = 0.6, $SE = 1.8$). However, the situation is different with the meditation level. Here, the difference is significant ($t = 3.0$, $p < 0.01$). The meditation level for single-tasks is 62.1, and only 58.8 for dual-tasks (the difference between means = 3.3, $SE = 1.1$).

Similarly to Experiment 1, no dual-task cost was observed in the context of the RT and average number of incorrect answers, either. As Figure 5.4B shows, the RT for single-tasks was 841 ms, and for dual-tasks it was only 5 ms more, i.e. 846 ms ($t = -0.2$, $p > 0.05$). Figure 4.8C shows, however, that the participants got the answers wrong equally often (or actually equally seldom) irrespective of whether the tasks were single or dual. During single-tasks, they tapped incorrectly 0.8 times on average, and 0.7 times during dual-tasks ($Z = -0.03$, $p > 0.05$), which means that almost each of them got a wrong answer only once in two single-tasks, and only once in two dual-tasks.

Figure 5.5 visualizes the dynamics of attention and meditation while carrying out two-back tasks, i.e. how their levels change in time. Figure 5.5A shows clearly that the dynamics of attention in single-tasks is not the same as the dynamics of attention in dual-tasks. There were also no significant correlations between its profiles ($p > 0.05$). This is refers to slightly longer periods of lack of concentration during dual-tasks and the fact that the dynamics of attention reflects the dynamics of the cognitive task during dual-tasks worse

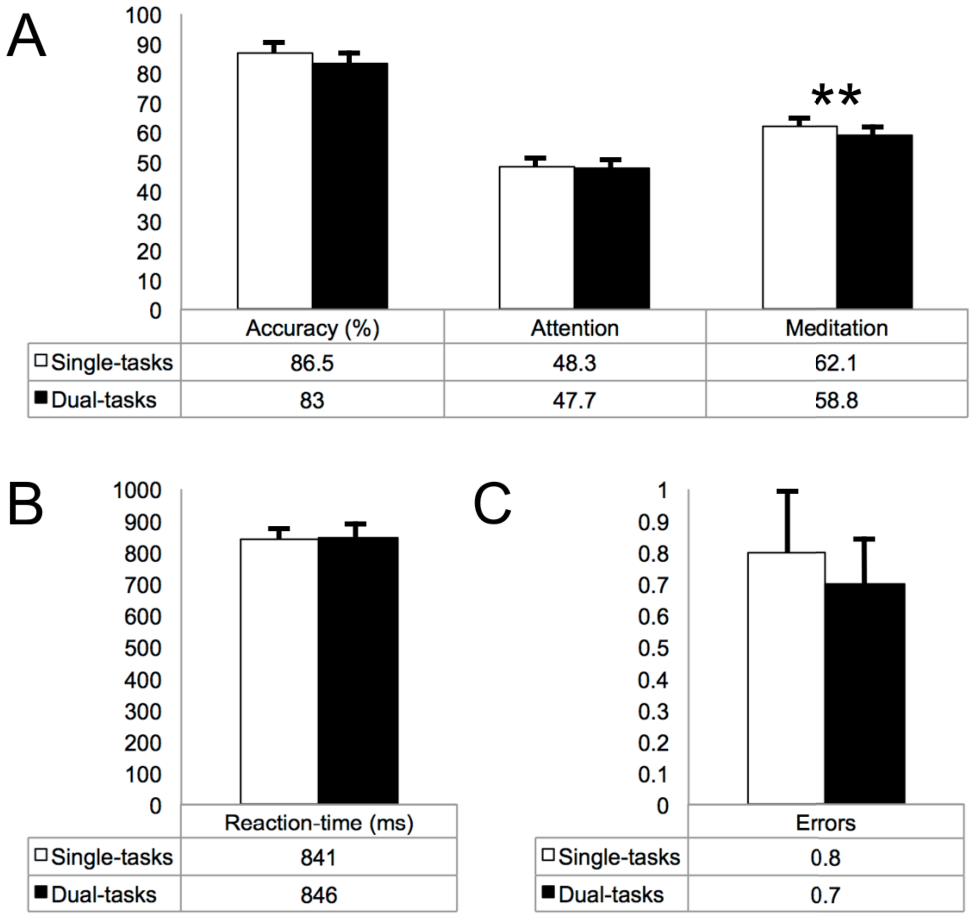


Figure 5.4. Results of the laboratory experiment: two-back tasks. **(A)** No dual-task cost was observed in the context of accuracy or attention level. This effect, however, is visible for the meditation level. **(B)** No dual-task cost was observed in the context of the average reaction time for correct answers **(C)** or in the context of the average number of incorrect answers, either. Only significant results are indicated here. Asterisks indicate significant *p*-values: $^{**}p < 0.01$. Error bars depict standard errors of the means. Source: own work.

than during single-tasks. Figure 5.5B shows that the case of the dynamics of meditation is not different. There were no significant correlations between its profiles ($p > 0.05$). Exactly as was the case in the context of results of Experiment 1, its profile for single-tasks is different than that of dual-tasks in the sense that starting a dual-task (first step with learning stimuli simultaneously) causes a lot of stress and that during the whole dual-task the stress is generally larger and lasts longer.

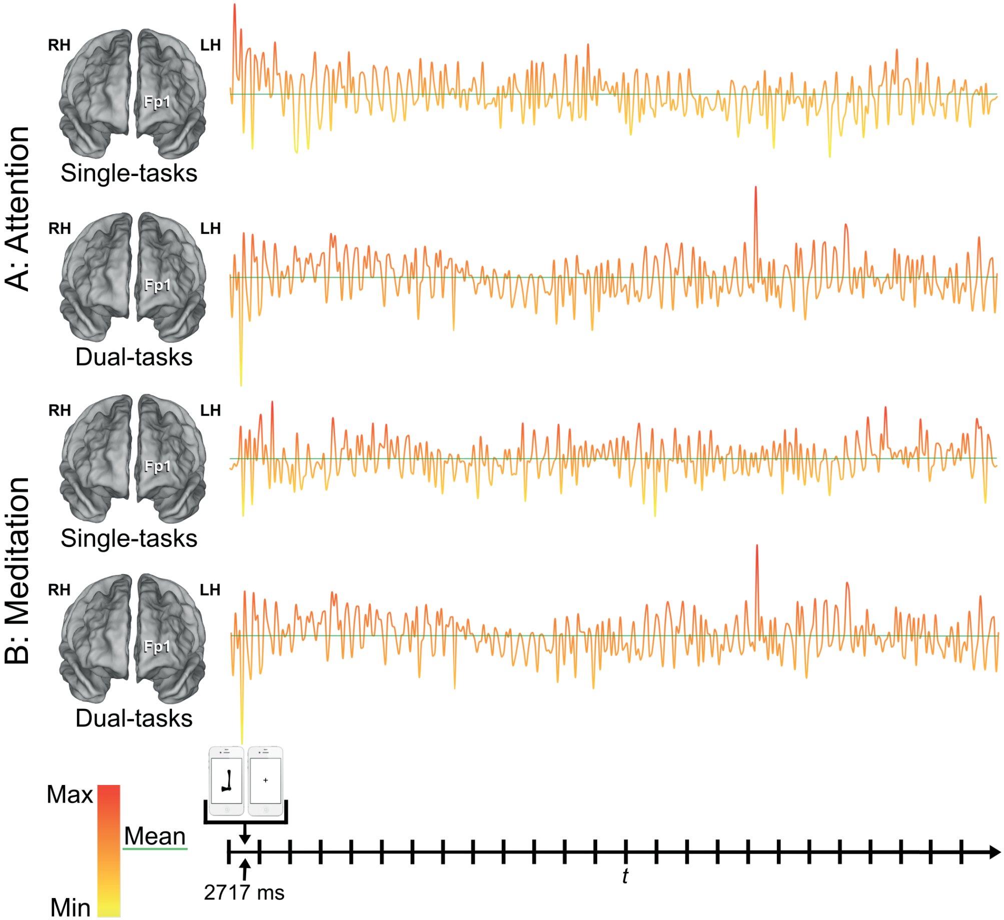


Figure 5.5. The dynamics of attention and meditation during two-back tasks (laboratory experiment). (A) The dual-task cost was observed in the context of the attention level variability in time, and its direction is linked to slightly longer periods of lack of concentration. **(B)** This effect was also observed for the meditation level variability in time. Starting a dual-task causes a lot of stress and its increased level accompanies carrying out the whole task. LH – left hemisphere, RH – right hemisphere. Source: own work.

CHAPTER 6

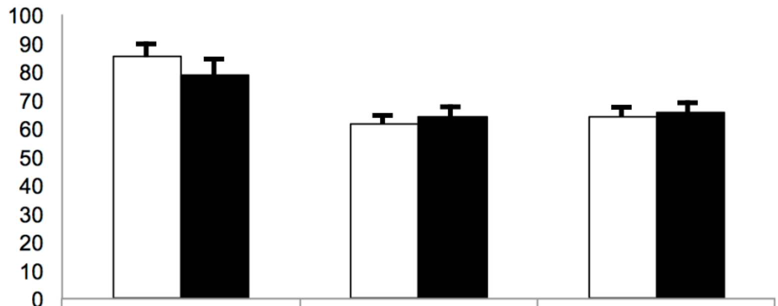
Supplemental analyses comparing outdoor and indoor learning

6.1. Data analyses

In order to verify if learning is more effective when one sits on a bench in a park (outdoor learning) than when one sits in the classroom or at home (indoor learning), supplemental analyses were run where independent data from Experiment 1 and Experiment 2 were compared. The Student's t-test (this time, however, for independent samples) or Mann-Whitney U test were used to compare variables. Similarly to previous analyses, the Kolmogorov-Smirnov test for normality was used to determine the appropriate statistical test (parametric or nonparametric). Finally, correlational analyses were used to investigate whether or not the dynamics of cognitive parameters both for outdoor and indoor learning share any common profiles. The adopted level of significance was also $\alpha = 0.05$. All statistical analyses were carried out using IBM SPSS Statistics 24.0.

6.2. Sternberg tasks

In the context of Sternberg tasks, no significant differences were observed between outdoor learning and indoor learning. Figure 6.1 shows that the average ACC for outdoor learning is 85.0%, and it is not significantly different from the ACC for indoor learning where it is 6.2% less, i.e. 78.8% ($U = 169.5$, $p > 0.05$). The case is the same in the context of the attention level and meditation level. During outdoor learning, the average attention level is 61.6, and during indoor learning it is 63.9 ($t = -0.8$, $p > 0.05$). On the other hand, the average meditation level during outdoor learning is 64.1, and during indoor learning it is 65.6 ($t = -0.5$, $p > 0.05$).



	Accuracy (%)	Attention	Meditation
□ Outdoor learning	85	61.6	64.1
■ Indoor learning	78.8	63.9	65.6

Figure 6.1. Results of supplemental analyses comparing outdoor and indoor learning: Sternberg tasks. No differences between indoor learning and outdoor learning were observed in the context of accuracy, attention level and meditation level. Error bars depict standard errors of the means. Source: own work.

Figure 6.2 visualizes the dynamics of attention and meditation during outdoor learning and indoor learning. It is clearly visible that even though the correlations between outdoor learning and indoor learning are significant (for attention: $p < 0.01$; for meditation: $p < 0.001$), the profiles of dynamics of these two properties are substantially more regular than for outdoor learning, and during outdoor learning they reflect the dynamics of the cognitive task better.

6.3. Two-back tasks

In case of two-back tasks, no significant differences were noticed between outdoor learning and indoor learning, either. Figure 6.3A shows that the average ACC for outdoor learning is 83.0%, and it is not significantly different from the ACC for indoor learning where it is 86.5% ($U = 181.5$, $p > 0.05$). The case is similar in the context of the attention level and meditation level. During outdoor learning, the average attention level is 53.4, and during indoor learning it is 5.1 less, i.e. 48.3 ($t = 1.6$, $p > 0.05$). On the other hand, the average meditation level during outdoor learning is 57.6, and during indoor learning it is 4.5 more, i.e. 62.1 ($t = -1.7$, $p > 0.05$).

No significant differences between outdoor learning and indoor learning were observed in the context of the RT and the average number of incorrect answers, either. As Figure 6.3B shows, the RT for outdoor learning is 928 ms, and for indoor learning it is 841 ms ($t = 1.9$, $p > 0.05$). Yet, we can talk of a certain very strong trend here, because $p = 0.7$. It means (even if *a priori*) that the

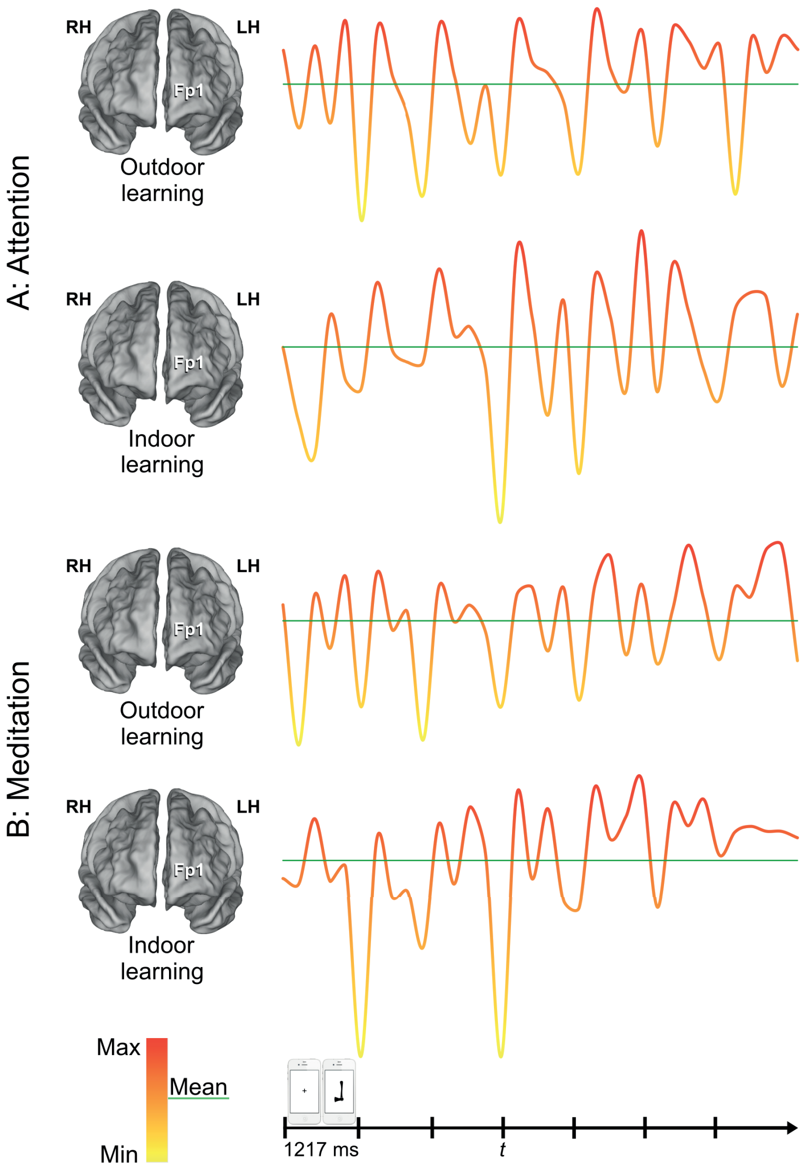


Figure 6.2. The dynamics of attention and meditation during outdoor and indoor learning (Sternberg tasks). (A) In the context of the attention level variability in time, significant correlations between outdoor learning and indoor learning were noticed, yet the profile of the dynamics of attention is substantially more regular for outdoor learning; during outdoor learning it reflects the dynamics of the cognitive task better. **(B)** In the context of the meditation level variability in time, significant correlations were noticed between outdoor learning and indoor learning, either; yet here the profile of the dynamics of meditation is substantially more regular than for outdoor learning. During outdoor learning stress moments are also slightly less intense. LH – left hemisphere, RH – right hemisphere. Source: own work.

participants tapped more quickly during indoor learning than during outdoor learning (the difference between means = 87 ms, *SE* = 46.1 ms). Figure 6.3C shows, however, that during indoor learning they also committed more errors (0.8 times in two tasks) than during outdoor learning where they were almost never wrong (0.1 times in two tasks). However, the difference observed (the difference between means = 0.7, *SE* = 0.4) is not significant, either ($U = 141.5$, $p > 0.05$), and it is also just a trend, and a considerably weaker one ($p = 0.1$).

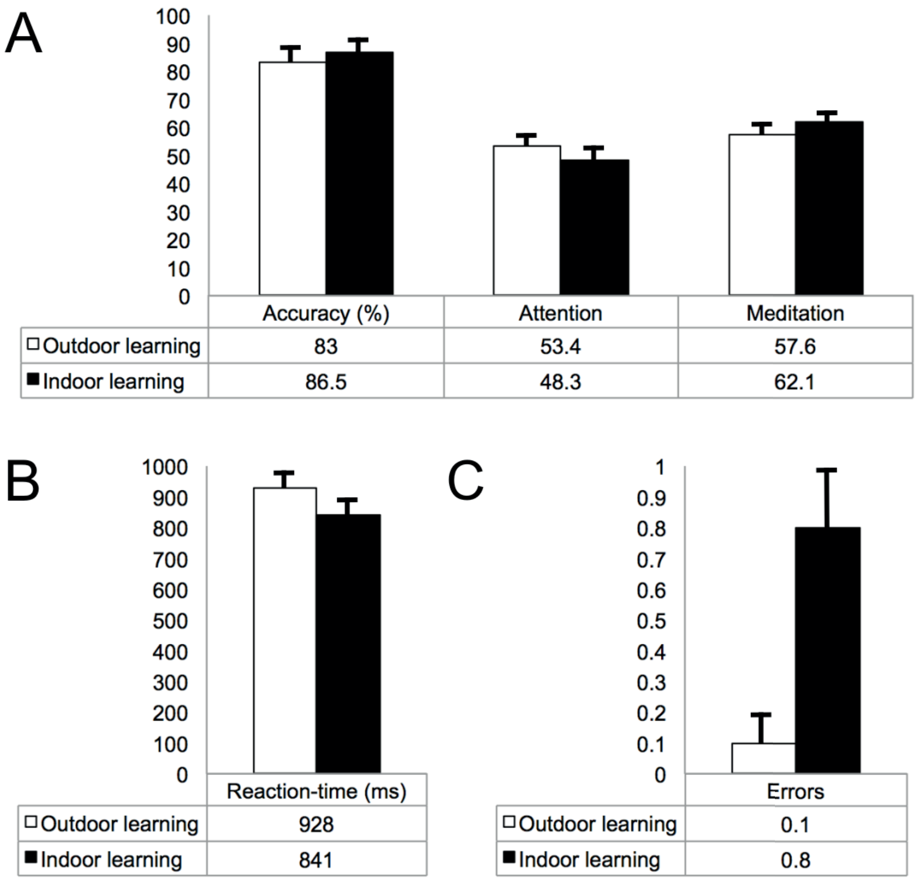


Figure 6.3. Results of supplemental analyses comparing outdoor and indoor learning: two-back tasks. **(A)** No differences between indoor learning and outdoor learning were observed in the context of accuracy, attention level and meditation level. **(B)** They were not observed in the context of the average reaction time for correct answers, either **(C)** or in the context of the average number of incorrect answers. One can still talk of a certain trend here that shows that the participants tapped more quickly during indoor learning than during outdoor learning, at the same time though they committed more errors during indoor learning. During outdoor learning they almost did not commit any errors at all. Error bars depict standard errors of the means. Source: own work.

Figure 6.4 visualizes the dynamics of attention and meditation during outdoor learning and indoor learning. Even though the correlations between outdoor learning and indoor learning are strongly significant (for both: $p < 0.001$), the profiles of dynamics for these two properties are slightly more regular for outdoor learning.

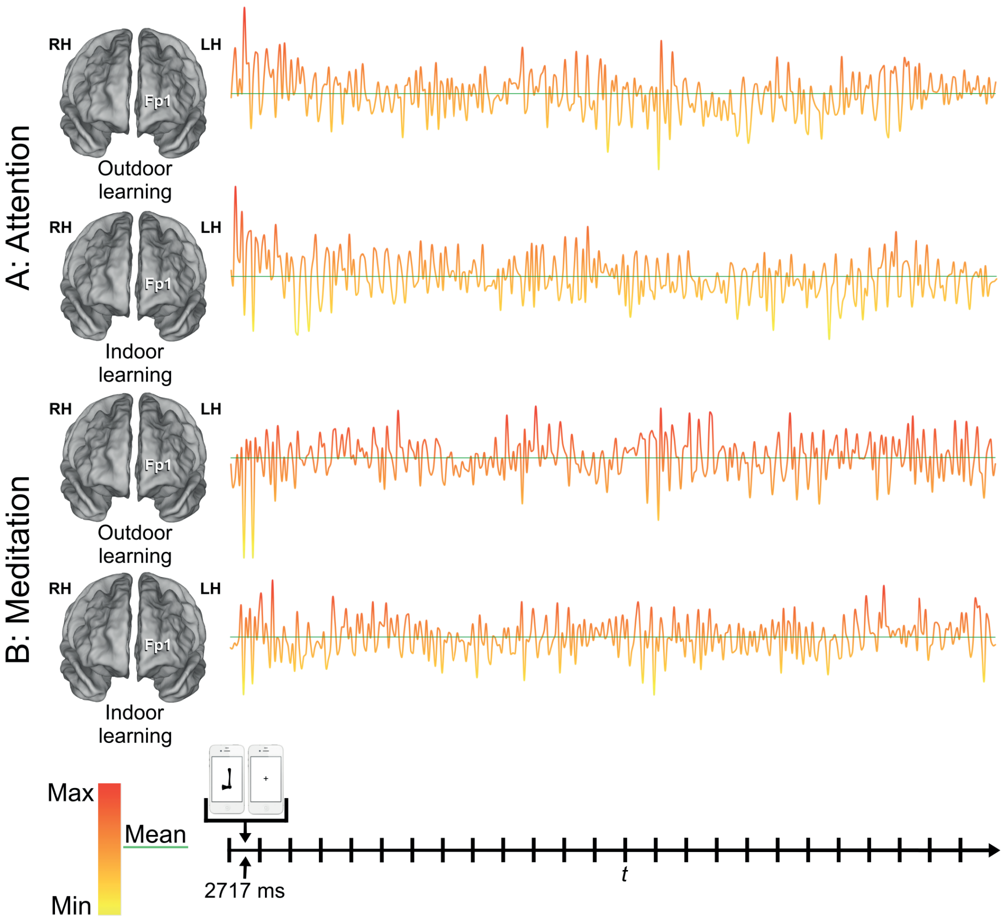


Figure 6.4. The dynamics of attention and meditation during outdoor and indoor learning (two-back tasks). (A) In the context of the attention level variability in time, significant correlations were observed between outdoor learning and indoor learning, yet the profile of dynamics of attention is slightly more regular for outdoor learning, which is reflected mainly in longer periods of lack of concentration during indoor learning. **(B)** In the context of the meditation level variability in time, significant correlations were observed between outdoor learning and indoor learning, either. However, the profile of dynamics of meditation is also slightly more regular for outdoor learning. During outdoor learning, stress moments are also slightly less intense. LH – left hemisphere, RH – right hemisphere. Source: own work.

Discussion and conclusions: how to learn in CyberParks?

The aim of this book was to present the state of knowledge on learning in CyberParks. This task was not easy, because the history of CyberParks has only just begun. In addition, no-one has actually written about or examined the educational sense of CyberParks yet[636]. The theoretical considerations included in Part 1 of the book allowed, however, to determine what learning in CyberParks is in the light of learning theories, and what technological solutions can already be used today with its framework. All in all, this theoretical study demonstrates that learning in CyberParks takes on the form of technology-enhanced outdoor learning (TEOL; a combination of the technology-enhanced learning concept [TEL] with the outdoor learning concept [OL]) and becomes an element of the smart learning idea, i.e. the most modern concept of ICT-supported learning. What is more, by using CyberParks in formal learning, learning in CyberParks becomes an element of smart education, i.e. concept of formal education in the smart city. To put it in simple words, learning in CyberParks is supposed to ensure that pupils have contact with nature (thus fighting at the same time its more and more widespread deficit), as well as encourage them to take up physical activity (thus fighting the more and more widespread sedentary lifestyle). In order to be able to learn in motion and close to nature, when learning in CyberParks (i.e. parks equipped with an additional, digital dimension) pupils are supposed to use mobile ICT tools with various applications (of the WayApp type) that use technologies such as, for example, GPS, QR codes or mixed reality. In this sense, the concept of learning in CyberParks is thus a certain answer to the problems of the contemporary culture, open to the needs of contemporary city dwellers.

636. P. Bonanno, M. Klichowski & P. Lister, A pedagogical model for CyberParks. In: C. Smaniotto Costa & I. Suklje-Erjavec (Eds.), *CyberParks – the interface between people, places and technology* (in print). Springer (2018).

Yet, this simultaneous combination of cognitive activity and physical activity causes some anxiety, because the dual-task cost concept suggests that this type of cognitive-motor interference can expose pupils to the risk of falling or having an accident while carrying out various activities in CyberParks, as well as it can weaken their cognitive abilities. If it was the case indeed, the idea of learning in CyberParks understood in this way would be deprived of any sense, all the more so of any educational sense. However, the dual-task cost concept has not been researched in this context yet.

To shed some new light on this issue, two experiments were carried out with the assumptions and results presented in Part 2 of the book. All in all, this empirical study demonstrates that outdoor learning is beneficial for the rhythms of the human brain, to use the term coined by Jensen[637]. The dynamics of attention and meditation seems to reflect the dynamics of the cognitive task better, and its profile seems to be more regular when the tasks are carried out outdoors as compared to the tasks carried out indoors (yet, it was manifested in the form of a trend). However, the rhythms of the brain start to undergo some interference when the cognitive task begins to be linked with a physical task. And so, during dual-tasks the periods of lack of concentration are extended and stress moments are intensified, and the dynamics of attention and meditation ceases to reflect the dynamics of the cognitive task. This effect was observed both when the participants walked in a park and when they simulated walking in a laboratory (in one case for two-back tasks it was manifested in the form of a trend; two-back tasks are, however, much easier than Sternberg tasks, which may explain why the dual-task cost was more visible for the latter).

The lack of stabilization in the rhythms of the brain observed during dual-tasks does not, however, affect the accuracy (ACC) of carrying out a given task, or the time needed to react to a certain stimulus, or even to a number of errors committed. This observation could suggest that in the context of cognitive processes, the dual-task cost concept is – playing with the language – "overcosted". However, the average ACC for all tasks in both experiments was as much as 83.0%, which may indicate that these tasks were simply slightly too easy (although it is not to say that any ceiling effects[638] occurred), and as a result the dual-task cost did not appear for these parameters (in future

637. E. Jensen, *op. cit.*, pp. 23-29.

638. R.A. Poldrack, Is "efficiency" a useful concept in cognitive neuroscience?. *Developmental Cognitive Neuroscience*, ***11***, p. 14 (2015); M. Scherr, A. Kunz, A. Doll, J.S. Mutzenbach, E. Broussalis, H.J. Bergmann, M. Kirschner, E. Trinka & M. Killer-Oberpfalzer, Ignor-

research, it would be good to use other paradigms that would burden the cognitive processes more; it is also worth testing the paradigms used in a situation of more intense physical activity, for example while marching with the speeds of 5 km/h, 6 km/h or even 7 km/h; such research, however, should be conducted only through simulations, because such a fast gait combined with a cognitive task can be dangerous under natural conditions). What is more, referring to the conclusions from the work by Fremerey and Bogner[639], it seems that even if the irregularity in the profiles of dynamics of attention and meditation during dual-tasks did not clearly affect the short-term effects observed, it rather most certainly destabilizes the process of consolidation[640], thus influencing the long-term learning effects. In future research, the level of recall of some elements after certain periods of time should also be examined, for example after a week, month and several months, i.e. the focus should be not only on the information kept in the working memory, but also on that transferred to the long-term memory. What is more, due to the fact that in the experiments described here the stimuli were of exclusively visual character, i.e. they engaged only the visual-spatial sketchpad[641], it is worth applying sound stimuli (ICT tools used in CyberParks are multimedia, thus they often convey information via sound) that engage the phonological loop, i.e. the second of the basic components of the working memory[642], in future research (even if they will not directly refer to examining the information stored in the working memory).

When discussing other limitations of the research conducted and to make recommendations for future research, it is impossible not to refer to the participants of the experiments described. Even though according to the standard

ing floor and ceiling effects may underestimate the effect of carotid artery stenting on cognitive performance. *Journal of Neurointerventional Surgery*, ***8***, pp. 750-751 (2016).

639. C. Fremerey & F.X. Bogner, Cognitive learning in authentic environments in relation to green attitude preferences. *Studies in Educational Evaluation, **44***, pp. 12-14 (2015).

640. S. McKenzie & H. Eichenbaum, Consolidation and reconsolidation: two lives of memories?. *Neuron*, ***71***, pp. 224-233 (2011); D. Oudiette & K.A. Paller, Upgrading the sleeping brain with targeted memory reactivation. *Trends in Cognitive Sciences*, ***17***, pp. 142-149 (2013).

641. M.W. Eysenck & M.T. Keane, *op. cit.*, pp. 214-224.

642. A.D. Baddeley, S. Gathercole & C. Papagno, The phonological loop as a language learning device. *Psychological Review, **105***, pp. 158-173 (1998); O. Gruber & D.Y. von Cramon, The functional neuroanatomy of human working memory revisited: evidence from 3-T fMRI studies using classical domain-specific interference tasks. *NeuroImage*, ***19***, pp. 797-809 (2003); M. Klichowski & G. Kroliczak, op. cit., p. 106.

of basic cognitive neuroscience research, late adolescents were examined, it is worth underlining that the brains of such subjects are much more similar to the brains of adults than children or teenagers[643]. As noticed by Jensen and Nutt, "a baby brain is not just a small adult brain, and brain growth, unlike the growth of most other organs in the body, is not simply a process of getting larger. The brain changes as it grows, going through special stages that take advantage of the childhood years and the protection of the family, then, toward the end of the teen years, the surge toward independence. Childhood and teen brains are impressionable"[644]. As shown by numerous studies carried out by teams led by Galvan[645], especially the teenage brain functions differently

643. J.D. Siegel, *Brainstorm the power and purpose of the teenage brain*. New York: Jeremy P. Tarcher / Penguin, pp. 1-6 (2013).

644. F.E. Jensen & A.E. Nutt, *The teenage brain: a neuroscientist's survival guide to raising adolescents and young adults*. London: Harper Thorsons, p. 24 (2015).

645. A. Galvan, T.A. Hare, C.E. Parra, J.P. Henning Voss, G. Glover & B.J. Casey, Earlier development of the accumbens relative to orbitofrontal cortex might underlie risk-taking behavior in adolescents. *The Journal of Neuroscience, **26***, pp. 6885-6892 (2006); A. Galvan, T. Hare, H. Voss, G. Glover & B.J. Casey, Risk-taking and the adolescent brain: who is at risk?. *Developmental Science, **10***, pp. F8-F14 (2007); B.J. Casey, S. Getz & A. Galvan, The adolescent brain. *Developmental Review, **28***, pp. 62–77 (2008); A. Galvan, R.A. Poldrack, C.M. Baker, K.M. McGlennen & E.D. London, Neural correlates of response inhibition and cigarette smoking in late adolescence. *Neuropsychopharmacology, **36***, pp. 970-978 (2011); A. Galvan, L. Van Leijenhorst & K.M. McGlennen, Considerations for imaging the adolescent brain. *Developmental Cognitive Neuroscience, **2***, pp. 293-302 (2012); A. Galvan, The teenage brain sensitivity to rewards. *Current Directions in Psychological Science, **22***, pp. 88-93 (2013); E.H. Telzer, A.J. Fuligni, M.D. Lieberman & A. Galvan, The effects of poor quality sleep on brain function and risk taking in adolescence. *NeuroImage, **71***, pp. 275-283 (2013); E.H. Telzer, A.J. Fuligni, M.D. Lieberman & A. Galvan, Meaningful family relationships: neurocognitive buffers of adolescent risk taking. *Journal of Cognitive Neuroscience, **25***, pp. 374-387 (2013); E.E. Barkley-Levenson, L. Van Leijenhorst & A. Galvan, Behavioral and neural correlates of loss aversion and risk avoidance in adolescents and adults. *Developmental Cognitive Neuroscience, **3***, pp. 72-83 (2013); E.H. Telzer, A.J. Fuligni, M.D. Lieberman & A. Galvan, Ventral striatum activation to prosocial rewards predicts longitudinal declines in adolescent risk taking. *Developmental Cognitive Neuroscience, **3***, pp. 45-52 (2013); E. Barkley-Levenson & A. Galvan, Neural representation of expected value in the adolescent brain. *Proceedings of the National Academy of Sciences, **111***, pp. 1646-1651 (2014); Y. Qu, A.J. Fuligni, A. Galvan & E.H. Telzer, Buffering effect of positive parent–child relationships on adolescent risk taking: a longitudinal neuroimaging investigation. *Developmental Cognitive Neuroscience, **15***, pp. 26-34 (2015); E.H. Telzer, A.J. Fuligni, M.D. Lieberman, M.E. Miernicki & A. Galvan, The quality of adolescents' peer relationships modulates neural sensitivity to risk taking. Social *Cognitive and Affective Neuroscience, **10***, pp. 389-398 (2015).

than the brain of an adult. As a result, we do not know if the – basic – results gathered here can be generalized to younger people. We can, however, predict that the consequences of the cognitive–motor interference during learning in CyberParks will be either the same for teenagers or children as those for late adolescents, or even clearer. Not only does the dual-task cost increase as the processes of brain ageing start (as demonstrated in Chapter 3), but it is also clearly higher in childhood and adolescence (than in adulthood). Based on the meta-analyses conducted by Ruffieux, Keller, Lauber and Taube[646], they noticed that a function of age in the context of the dual-task cost takes on a U-shaped pattern. This is confirmed by research results by Hagmann-von Arx, Manicolo, Lemola and Grob[647]. These researchers, however, analysed the dual-task cost in the motor context, and not in the cognitive context, and as suggested by research results by Anderson, Bucks, Bayliss and Della Sala[648], the weakening of cognitive processes in the course of dual-tasks does not necessarily have to be stronger for children or teenagers as compared to late adolescents or adults. In the context of cognitive processes, we can thus come across a reverse L-shaped pattern and not the U-shaped pattern. Nevertheless, this indicates that the consequences of the cognitive-motor interference during learning in CyberParks for teenagers or children are at least the same as those for late adolescents. In order to be certain of it, however, additional experiments (not so fundamental) should be conducted where the participants would come from these age groups.

By referring to the research that used the currently most advanced research procedure in educational studies conducted by Dikker, Wan, Davidesco, Kaggen, Oostrik, McClintock, Rowland, Michalareas, Van Bavel, Ding and Poeppel[649] that consisted in using 12 sets of mobile EEG while examining interactions in the school classroom, future studies could also additionally

646. J. Ruffieux, M. Keller, B. Lauber & W. Taube, Changes in standing and walking performance under dual-task conditions across the lifespan. *Sports Medicine*, ***45***, pp. 1741, 1752 (2015).
647. P. Hagmann-von Arx, O. Manicolo, S. Lemola & A. Grob, Walking in school-aged children in a dual-task paradigm is related to age but not to cognition, motor behavior, injuries, or psychosocial functioning. *Frontiers in Psychology*, ***7***, pp. 4-11 (2016).
648. M. Anderson, R.S. Bucks, D.M. Bayliss & S. Della Sala, Effect of age on dual-task performance in children and adults. *Memory & Cognition*, ***39***, pp. 1243-1251 (2011).
649. S. Dikker, L. Wan, I. Davidesco, L. Kaggen, M. Oostrik, J. McClintock, J. Rowland, G. Michalareas, J.J. Van Bavel, M. Ding & D. Poeppel, Brain-to-brain synchrony tracks real-world dynamic group interactions in the classroom. *Current Biology, **27***, 1375-1380 (2017).

examine the (brain-to-brain) interaction of the participants (irrespective of their age) of learning in CyberParks. This could lead to an explanation on whether learning in CyberParks is a concept of individual learning or rather of group learning.

To sum up, this theoretical and empirical study shows that learning in CyberParks is a very interesting concept of both informal and formal learning directed at contemporary (and future) city dwellers. However, before CyberParks become spaces for learning, the CyberParks idea itself should be redefined in a sense. In CyberParks, people should be physically active, and as demonstrated in the theoretical part of this book, ICT tools can encourage such activity, and even coordinate such activity, by providing visitors to CyberParks a suitable amount of movement. Yet, the crucial cognitive activity carried out in CyberParks should be separated from physical activity. If someone thus wants to learn in CyberParks via ICT tools, they should sit on a bench, grass or some other place, and learn with the use of applications that do not require them to move. Staying close to nature improves the functioning of the human brain, which is why such learning is more effective than learning carried out indoors or outdoors, but without contact with the greenery. What is more, it is also healthier, and it can be easily organized in such a way that the learners are physically active during breaks from learning. When designing CyberParks, one should not only consider their technological infrastructure, but also plan some space in them for comfortable seating and use of ICT tools (for example, they should include tables with wireless chargers, benches equipped with power sources, or garden houses of various types to give shade or shelter on a rainy day, or even something like an outdoor classroom). From this perspective, learning in CyberParks thus becomes a very important concept whose implementation into the reality of formal education may provide an answer to many problems of the contemporary educational institutions, for example linked to students' lack of frequent contact with nature and the consolidation of their sedentary lifestyle. What is more, the concept of learning in CyberParks seems to represent some balanced (healthy) approach to the level of ICT use in education[650]. In CyberParks we are supposed to use ICT tools, but we are also supposed to be close to nature, i.e. a reality that has not been technologized. To paraphrase the quote that opens the considerations in this book, it can thus be stated that the concept of learning in CyberParks is

650. M. Thomas, Digital education: opportunities, challenges, and responsibilities. In: M. Thomas (Ed.), *Digital education. Opportunities for social collaboration* (p. 3). New York: Palgrave Macmillan (2011).

based on the following rule: the more ICT in learning (the more TEL is used), the more we have to learn outside (the more we need TEOL).

The concept of learning in CyberParks understood in this way can, however, be opposed to by teachers. Studies by Ucus[651] show that most often teachers perceive outdoor activities are linked only to physicality, or to exploring nature or interesting places. Will they then assume that when the weather is good, it is better to learn in CyberParks than in the classroom? Moreover, research by Gehris, Gooze and Whitaker[652] with the use of the focus groups method show that in the context of all innovations linked to OL, teachers demonstrate considerable distrust and expect comprehensive – methodical even – training. The case is similar with pre-service teachers. Even though they are taught to search for qualitatively best educational solutions[653], they do not – as demonstrated by Klichowski and Smaniotto Costa[654] as well as by Klichowski, Bonanno, Jaskulska, Smaniotto Costa, de Lange and Klauser[655] – have a positive attitude towards innovative solutions that change the traditional education paradigm through ICT, such as smart education, and they do not evaluate the CyberParks themselves as encouraging to use them for educational purposes. This is hardly surprising, because it is known that teachers and pre-service teachers evaluate educational activities from the perspective of their own educational experience[656], where simplified binary relationships occurred that radically separated the home from the school, the school from the city, formal learning from informal learning, as well as they showed that the school is the place for learning, and green areas are a space

651. S. Ucus, Elementary school teachers' views on game-based learning as a teaching method. *Procedia – Social and Behavioral Sciences, **186***, p. 408 (2015).
652. J.S. Gehris, R.A. Gooze & R.C. Whitaker, Teachers' perceptions about children's movement and learning in early childhood education programmes. *Child: Care, Health & Development, **41***, pp. 123, 129 (2015).
653. H. Fives, N. Lacatena & L. Gerard, Teachers' beliefs about teaching (and learning). In: H. Fives & M.G. Gill (Eds.), *International handbook of research on teachers' beliefs* (pp. 252-253). New York – London: Routledge (2014).
654. M. Klichowski & C. Smaniotto Costa, op. cit., pp. 160-164.
655. M. Klichowski, P. Bonanno, S. Jaskulska, C. Smaniotto Costa, M. de Lange & F. Klauser, op. cit., pp. 5-7.
656. R.H. Chant, T.L. Heafner & K.R. Bennett, Connecting personal theorizing and action research in preservice teacher development. *Teacher Education Quarterly, **31***, pp. 25-42 (2004); S. Jaskulska, Graded assessment of pupils' conduct as a research object. Discovering a hidden school upbringing curriculum. In: E. Bochno (Ed.), *School in Community. Community in School* (pp. 129-139). Torun: Adam Marszalek Press (2013).

for physical activity, and maybe natural history classes, only[657]. The concept of learning in CyberParks, and more broadly smart education, thus shatters the traditional way of thinking about education; however, as indicated in the theoretical part of the book, this sort of change in the educational paradigm is necessary for the contemporary society.

657. J.P. Daley, Deconstructing formal and informal learning spaces with social networking sites. In: M. Thomas (Ed.), *Digital education. Opportunities for social collaboration* (pp. 221-222). New York: Palgrave Macmillan (2011).

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Appendix A

Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action TU1306: Fostering knowledge about the relationship between Information and Communication Technologies and Public Spaces supported by strategies to improve their use and attractiveness (CYBERPARKS)

European Cooperation
in the field of Scientific
and Technical Research
- COST -

Brussels, 22 November 2013

COST 085/13

MEMORANDUM OF UNDERSTANDING

Subject :	Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action TU1306: Fostering knowledge about the relationship between Information and Communication Technologies and Public Spaces supported by strategies to improve their use and attractiveness (CYBERPARKS)

Delegations will find attached the Memorandum of Understanding for COST Action TU1306 as approved by the COST Committee of Senior Officials (CSO) at its 188th meeting on 14 November 2013.

MEMORANDUM OF UNDERSTANDING
For the implementation of a European Concerted Research Action designated as

COST Action TU1306
FOSTERING KNOWLEDGE ABOUT THE RELATIONSHIP BETWEEN INFORMATION AND COMMUNICATION TECHNOLOGIES AND PUBLIC SPACES SUPPORTED BY STRATEGIES TO IMPROVE THEIR USE AND ATTRACTIVENESS (CYBERPARKS)

The Parties to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 4114/13 “COST Action Management” and document COST 4112/13 “Rules for Participation in and Implementation of COST Activities”, or in any new document amending or replacing them, the contents of which the Parties are fully aware of.

2. The main objective of the Action is to is to strengthen the dialogue between the research communities / areas involved in the production of public spaces and the ICT development in order to cross-pollinate both fields, generate mutual improvement activities, spark new ideas, and trigger new research lines and projects.

3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 52 million in 2013 prices.

4. The Memorandum of Understanding will take effect on being accepted by at least five Parties.

5. The Memorandum of Understanding will remain in force for a period of 4 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of section *2. Changes to a COST Action* in the document COST 4114/13.

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A. ABSTRACT AND KEYWORDS

The Action's main objective is to create a research platform on the relationship between Information and Communication Technologies (ICT) and the production of public open spaces, and their relevance to sustainable urban development. The impacts of this relationship will be explored from social, ecological and urban design perspectives.
ICT is a driving force, media and tool, which operates as a mediator between users and their virtual and real worlds. Public spaces have multiple functions, including social gathering places where outdoor interactions between people can occur and communication and information exchange can take place.
The relationship between ICT devices and public open spaces is not new but is growing at a rapid pace, becoming a challenge for ICT experts, spatial planners and social scientists. ICTs cause and enable innovative outdoor social practices which challenge spatial and social experts to use them in policies, methodologies, design and research to produce responsive and inclusive urban places.
The Action deals with opportunities and risks ICTs offer to the user, via the appreciation, design and usage of public spaces. It exploits the benefits of interweaving a green experience with digital engagement via sharing knowledge, experiences and ideas, and analysing public spaces.
Keywords: ICT, Mobile Technology and Social Networks, Public Open Space, Place Design and Users, Spatial Development and Urban Resilience, Location Based Gaming, Biophilia

B. BACKGROUND

B.1 General background

In the last decade ICT have grown into an important social medium. People build and maintain their social relationships through various social media, and increasingly this also impacts the way they organise their everyday lives in the city. New socio-spatial practices have emerged, both on a collective level (flash mobs, the use of ICT in various political uprisings and riots, bike and car sharing programs) as well as on an individual level (the use of navigation systems and recommendation software to find interesting places to visit, the annotation of places through Twitter, Facebook or review sites such as Yelp, using smart phones to arrange spontaneous meetings with friends or strangers, talking via mobile phones or exposing private topics in public or on social networks, posting private photos, sexual desires, problems in school).
The high levels of mobile phone and internet penetration is underpinning a strong correlation

between the real (physical) and virtual (digital) domains, even if the use of digital tools for personal and social interactions for increasing links to the real world remain unchanged. People of all ages still need contact with nature and with other people, in order to develop different life skills, values and attitudes, to be healthy, satisfied with their lives and environmentally responsible. Recent research into biophilic design, restorative environments, nature deficit syndrome and technobiophilia demonstrates that a green environment is essential to well-being in both analogue and digital surroundings.

The Action addresses the interactions between digital and physical domains, which used to be considered as largely separate; nowadays, with the increased profusion of wearable ICT, mobile connectivity and interaction possibilities via social media, profoundly influence our conception of time, space and place, social relationships, citizenship and identity. Digital features are inevitable part of contemporary life but may incur as yet unknown consequences. There are different examples of blended digital/public open spaces, e.g. digital displays in cities, wi-fi provision in parks and squares, on-the-spot tourist information, broadcasting and interactive art performances, urban games, etc. At present, these are novel, uncommon and diverse, but they are increasing. Even if they are not goal-oriented towards urban spaces, they influence the perception and use of such spaces, adding new dimensions to their planning and design, e.g. new street furniture elements.

A relevant aspect of ICT is their ability to enhance communication with (potential) users and allow creative participation and community formation. ICT can be a tool for scenario simulations or to enhance the attractiveness and responsiveness of the public spaces. Users can share information, expose their opinions, needs and desires. GPS and other GIS supported devices can greatly inform about usage-spatial relationships. These pose a challenge for spatial planers to respond creatively and holistically.

ICT in public spaces may also bring threats that should be taken into account like electronic aggression when ICT are used to conduct hostile acts. Such aspects, from the users' view in regard to their needs as well as from the designer's open research opportunities for meeting the social needs and public preferences.

A high number of projects, activities and initiatives take up aspects of interaction among users, ICT and social behaviour (e.g. MobileCity, Cyberbullying, ISTME), others set up on ICT for spatial analyses, planning methodologies and public involvement (Click Your Way, Behaviour Mapping, People Friendly Cities), as well as a series of urban games. Although ICT relies on interactions among users, very little is known about **ICT-users related to public open spaces**. Interventions of digital media are supposed to change the perception of today and future public space role, design and usage. In fact we don't know yet what those changes mean for public spaces' character and

design.
The Action explores interactivity, the spatial and social aspects of ICT in urban cultures, their impacts, opportunities and risks that have not yet been systematically compared, discussed and evaluated. The consequences of this relationship are not yet fully investigated, long-term experiences and analyses do not yet exist, meaning that ultimate evaluation of the consequences of ICT in public spaces is still awaited. This fact accompanied by rapid development and increasing application possibilities, challenges ICT experts, urban designers and social scientists.
Thus, tackling an emerging topic, as the relationship between ICT and urban development, calls for broad interdisciplinary and international collaboration. Therefore, COST offers an ideal framework for exploring this challenge, allowing networking and capacity-building activities. This is an important feature to bring together a high number of researchers working on related themes, to enable a regular scientific exchange as well as to gather together the fragmented research within scientific areas and countries. The Action acts through a transdisciplinary network of scientists, researchers, ICT experts, urban designers, landscape architects, stakeholders and citizens; it will enable a look at long term perspective and a bigger picture of the implications, opportunities and challenges the amalgamation of the virtual and real worlds pose.
CyberPark, as a COST Action, aims at providing necessary steps towards EU cooperation in science and technology to foster basic understanding of related topics and enabling further development of new ICT-based applications through integrating multidisciplinary research teams, as well as comprehensive training for students and early stage researchers.

B.2 Current state of knowledge

The Action explores actual topics related to future development of ICT for the purpose of recognition of values of urban public open spaces, contemporary and future life styles, needs and challenges. We are experiencing a digital era, an era of electronics and computers, of real-time transmission of data and immense computing power. It is astounding how developments in electronics, information and telecommunications permeate our daily lives, and almost every day something new is aggregated. Also in urban development ICT have been introduced in various ways.
Public open space, for the purpose of **CyberPark**, is defined as a collective term and in its broadest sense, as an open space, i.e. unbuilt space inserted into the urban fabric, planned, designed and managed with particular purpose and used by the general public, regardless ownership or in terms of rights. The network of public open spaces includes both the natural and built environment.

Among them are streets, squares, plazas, market places, parks, greenways, community gardens, playgrounds, waterfronts, etc., each one playing a vital role in the city, whether for mobility, for social life, for leisure and recreation, and/or on account of their scenic value and ecological, environmental merits for nature and landscape preservation. They are social sites for people from different generations, gender, social status and culture, as they afford the common ground for communication and information exchange. They are places to express cultural diversity, are places to see and be seen in or even be anonymous in a crowd (Thompson 2002). Individually the social interactions are important for defining a sense of place, for contributing to our physical, cultural and spiritual well being, for the personal development and social learning and for the development of tolerance (Thompson 2002, Šuklje 2010). In a political sense they offer a forum for political representation, display and action (Habermas 1990). Being 'open-to-all' (Thompson 2007, 2002) they are neutral territories, which are inclusive and pluralist (accepting and accommodating difference). This concerns also their use for public purposes, such as to hold collective celebrations or to influence collective decision-making (Storck 2011, Parkinson 2008). This brings about the symbolic character public spaces can embody as representative of the collective and of sociability (rather than individuality and privacy (Thompsom 2002, 2007).

The quality of being an enabling resource for social interrelations confers on the public spaces a positive connotation, but one has also to be objective; the urban society is heterogeneous and has distinguishing objectives and features in its social organisation. Even if public spaces offer opportunity for a kind of public privacy, e. g being within a crowd but interacting via mobile phones is a private action.

Information and Communication Technologies (**ICT**) for the purpose of CyberPark refers to technologies that provide access to information through telecommunications. This includes the Internet, wireless networks, tablets and cell phones, and other communication mediums. ICT provide society with a vast array of new communication capabilities. It enables people to communicate in real-time with others in different locations using technologies such as instant messaging, voice over IP, and video-conferencing. Moreover, social media websites allow users to contact friends and communicate with others across the world on a regular basis. Social media is turning to be a big part of contemporary life. For this reason, ICT is often studied in the context of how modern communication technologies affect the interactions between people and society. Recently more studies are devoted to negative aspects of this interaction. One example threatening human behaviour or new form of aggression, that has increased among adolescents and adults during recent years in the virtual environment of the Internet is called *Cyberbullying* (Katzer, 2007; 2009; 2011, 2013, Fetchenhauer & Belschak, 2009; Li, 2006).

Relevant for topic of interaction between ICT and public spaces concerns the features of ICT to allow on-demand access to content anytime and from nearly anywhere. Also the property to engage individual users as well as groups of people to interact and congregate online and share information, and this outdoors, are relevant aspects. The impacts of ICT and wi-fi reaching public spaces is difficult to anticipate, as well as whether this will lead to the redesign of public spaces, but this inclusion is already challenging designers and landscape architects to meet the needs of people living in an increasingly connected world. The wi-fi hotspots do not require only new signs to inform their existences but for making the use of ICT and mobile devises outdoors more comfortable already new street furniture is being designed. This new furniture could have further influence on the urban landscape. For the moment the interactions of ICT and public spaces can be seem in three different ways:

1) The use of ICT devices in public spaces (phoning, texting, wi-fi, gaming),

2) The ICT as information transport media (internet, newsletter),

3) ICT as a tool for social reporting and planning (e-planning) - this includes the possibilities the ICT offer for connecting people on urban issues (enhancing participation).

The Action is based on existing knowledge and experience of importance of public open space for urban sustainability. Several works highlighted the social, ecological and economic benefits of public open spaces, from a single as well as from a cumulative perspective, among these authors to be mentioned are Radovanova (2008, 2013), Šuklje (2010), Smaniotto (2012). Woods (2012, 2013) examines the relationship between environment, physical activities and health. Other authors analysed already some aspects of the interrelationship between ICT and public spaces. Smaniotto (2013) listed several examples of these interactions; De Lange (2013) explores the affect of ICT in a *hybrid urbanism*. Meyrowitz (1985) and Hampton *et al*. (2009) report on social behaviour and social interactions under the influence of ICTs; Hampton & Gupta (2008) on the use of wi-fi in public and semi-public spaces, Graham (2004) on the virtual city and cyberspace. Graham & Auguri (2007) make connections among the virtual city, crisis of public space, social polarisation and the access to computers and telematics, and Souza e Silva (2006) deals with the hybrid space, a mash-up of real-world spaces with mobile technology. Pauwels (2012) proposes a multimodal framework for analysing websites as cultural expression. Recent research into the connections between technology and biophilia (Thomas 2013) concluded that the preponderance of nature metaphors, memes and images to be found in cyberspace (e.g. surfing the internet, twitter stream, the cloud, viruses, worms and bugs) can be understood as a way by which users imagine virtual space as a familiar physical ecology. The concept of biophilia was developed by biologist E. O. Wilson to describe 'the innate attraction to life and lifelike processes' and Thomas argues that ‘technobiophilia’, the ‘innate attraction to life and lifelike processes as they appear in technology’, is a way to access the restorative qualities of biophilia in a highly technology-mediated environment and thereby alleviate mental fatigue and enhance the capacity for directed attention. Biophilic design is becoming commonplace in contemporary architectural practice, but little work has been done to integrate it into digital technologies. An interesting example is *Escale Numérique* in Paris, a wi-fi access point on the Champs-Elysées which features a sustainable green roof covered with plants and supported by a cluster of wooden poles, beneath which are concrete swivel seats with mini tables and plugs on their base. There is also a large touch screen, looking something like a gigantic smart phone that provides updated information about services in the city for visitors or those without their devices. *Escale Numérique* allows everyone to benefit, like a real public service, from a high-speed wi-fi connection by raising it from beneath the ground’.

B.3 Reasons for the Action

Despite significant spread and use of ICT-based devises in public spaces and for their production, there is a lack of coordinated and interdisciplinary exchange of knowledge between researchers and experts from different scientific domains.
Furthermore, research and development of ICT devices, even when funded within the EU programmes, is still fragmented, and often seem only as “service” to develop new applications – critical mass is thus missing. In order to gain a broad overview of possibilities, opportunities and risks and to obtain the utmost of this platform technology, it is important to establish cooperation between research groups from different domains. This is why it is necessary to launch this COST Action. This cooperation will enable cross-fertilisation of different areas and allow the exchange of experience and knowledge.

B.4 Complementarity with other research programmes

As shown in chapters *B.2 Current state of knowledge* and *D. Recent Publications* **CyberPark** can rely on different ongoing and completed research projects on related subjects. Although these do not have the same focus they pave the way for the Action, than one of its objectives is to put together the available knowledge and interweave them within another context - a context that could be representative for Europe. Hence, the Action is backed by existing national research and could be a complement to enable a European perspective that otherwise are not be possible.
As being innovative in its contents and in the way to explore the available knowledge also ensure to

pollinate both fields, generate mutual improvement activities, spark new ideas, and trigger new research lines and projects.
The Action's objectives are:

1. To bring together in a coordinated way the European research community in different domains (ICT, communication, urban development and urban sociology) and creating a shared understanding of the methods and possibilities of ICT to improve public spaces, their research and public involvement into their planning and design, and thus to enhance public involvement in sustainable urban development,

2. To initiate and sustain an open and intense dialogue between researchers of different research areas, thus providing a stimulating environment for sparking ideas that result from the synergies inherent in bringing different research fields closer together,

3. Synthesise and disseminate the new and revised knowledge resulting of the Action (focussed on public spaces - the places of publicness and social interactions) to the scientific community, policy makers and experts,

4. To increase the awareness on new applications and technology of developers and users of the new tools to promote changes in people's behaviour, towards more active life styles,

5. Establish a common database where all pertinent knowledge, via published papers and books to related topics will be made available,

6. To stimulate and promote collaborative research by structuring and developing proposals for future applications of additional funding on the national and European level,

7. To evaluate and further develop existing ICT-based devises and applications, and explore new applications opportunities,

8. To synchronise academic and industrial research that may result from the intersection of ICT and public space and their relevant users, and therefore promote existing and establish new links with industrial partners in new commercial applications.

C.3 How networking within the Action will yield the objectives?

In order to achieve the Action's objectives it is of outmost importance to reach and activate a critical mass of experts on ICT, urban and landscape planning, sociology, behavioural and health issues. This will be achieved by using networking and capacity building activities provided by COST, thus providing the possibility to meet and discuss on a regular basis. This is even more important since participants are coming from different scientific domains and have different backgrounds and experience. For those entering the field (with special emphasis on ESR) basic knowledge on ICT applications for social, behavioural and health research will be clearly presented in training schools. The effective exchange of ideas and knowledge between experts, researchers and policy makers will be achieved by promoting meetings, workshops and symposia.

An important way to achieve the Action's objectives is the analysis of case studies and research exchange visits between different partners. These STSMs not only means the gathering of new valuable knowledge, especially in experimental methods, but also paving the way for future collaborations.

Additionally to the networking activities, the establishing of an internet and blog site with updated information on current results, existing protocols, applications and publications will promote fundamental research, development of new applications and spreading the existing ones will lead to the final achievement of the Action's objectives.

The multidisciplinary competences of the research partners, as well as their specific methods and equipments, will be brought together in a unique platform, allowing new concepts and findings to be discovered.

C.4 Potential impact of the Action

The Action provides a forum for cross-sector working (researchers, urban designers & developers, ICT experts, creative industries experts) and for complex exhausted analyses of public spaces, ICT and their mutual impacts. It offers an ideal place to share knowledge and experiences on ICT, social behaviour and urban design, and their impacts on life styles. The Action explores different topics related to future development of ICT for the purpose of recognition of values of open spaces, especially in the cities, contemporary and future life styles, needs and challenges. The focus is on exploration of:

1. different ways to look at real (urban) spaces,

2. opportunities of ICT use in public spaces,

3. ICT development to challenge people to use public spaces (in new and more frequent ways),

4. new challenges to bring people outdoors and stay there for inter-active communication, recreation and learning,

5. opportunities of adopting ICT for research needs.

The Action will generate knowledge on creative industries, increasingly important to urban resilience, economics, and well-being of cities. It will deliver arguments and evidences for the Horizon 2020 policy priorities, including health, demographic change and wellbeing; smart, green and integrated transport; and inclusive, innovative and secure societies.
The Action is expected to speed up the international development of this new research field and to improve interdisciplinary cooperation. Researchers, experts, planners and stakeholders will benefit from the exploration of new ideas and approaches to better address the increasing challenge in ICT development for contemporary/future society as well as in public spaces development and design.

C.5 Target groups/end users

There are four main aspects of the Action which identify target groups and end users:

1. The **scientific community**: The Action will provide a series of coordinated activities to initiate and strengthen an interdisciplinary dialogue that permits knowledge transfer and expertise between researchers more effectively and efficiently. The scientific community also includes **Early Stage Researchers** (ESRs), who will be involved in all research activities. **CyberPark** will provide a suitable platform to grasp their creativity in a cross-sectoral and international context as well as new inputs for their own development and wherever possible, practical support to build a successful academic career.

2. **Decision makers and national, regional and local stakeholders**, some of them already involved in the Action, will enable the development of policies, planning

the Action to not represent duplication to existing research in other European frameworks.

C. OBJECTIVES AND BENEFITS

C.1 Aim

CyberPark aims at sharing and advancing knowledge on the interactions among public spaces - urban design - urban sociology - behaviour research - ICT. It focuses on:
- Coordinating and enhancing research efforts in how to deal with opportunities and/or risks of ICT usage in public spaces, and the meaning for design practice,
- Enhancing and testing research methodologies into a new context, considering the social function of public spaces,
- Establishing links and promoting collaboration among experts, e.g. creative industry, practice and consultancy.
- Forming self sustained empirical knowledge which emerges from use of ICT by place users, and via experimental research gaining empirical knowledge and synthesising the impacts of ICT on public spaces into a set of guidelines for city planners, urban developers, urban policies, regulatory and decision-making bodies.

Thus considering ICT as:
- a potential for social innovation and well-being and as method for social research: What changes and challenges do ICT pose for urban spaces and therefore also for human behaviour?
- innovative tools for better, bottom up/participative design: How can we create contemporary public spaces that are thrilling and attractive for cyber enthusiasts and which encourage people to enhance social contracts and practice physical activities outdoors? What help can ICT offer to reduce wrong usage of ICT (e.g. internet-addiction) and bring more people outdoors?
- a potential for enhancing and building up (digital) sense of (real) place: How to use ICT and urban games to connect virtual and real places and bring (new) users outdoor?
- a motor for changes (1) in the urban environment (urban spaces, streets, infrastructure, street furniture, etc.), and (2) on social networks for private topics and family, for business and school, for fun and leisure.

C.2 Objectives

The main objective of the Action is to strengthen the dialogue between the research communities / areas involved in the production of public spaces and the ICT development in order to cross-strategies, design concepts and projects for the interaction of ICT and public spaces. Especially the **Pool of good practices** will inspire new practices towards more sustainable urban landscapes and green experiences.

3. **ICT developers -** the gained knowledge will also serve as frames for cooperation with ICT developers, manufacturers and, eventually, users of innovative communication devises. The Action will put efforts to share technological knowledge and innovation and for building in building and cementing contacts with industrial partners.

4. **ICT users and public open space users** - this group will benefit from the Action in the way that advices and recommendations, based on the gathered evidences and experiences, will be widely communicated. For this **CyberPark** will take account of the variety and intensity of potential uses and users' groups (children, young people, pupils and students, active citizens, elderly, etc.) and not a preferable standard based approach - as in the current praxis of production of public space.

D. SCIENTIFIC PROGRAMME

D.1 Scientific focus

The scientific programme is focused on a pragmatic approach to create and disseminate a new understanding of the interactions opportunities and possibilities the ICT with the public spaces. **Case Study analysis** combining different methods and approaches, will allow a broader view on this emerging topic. At the time of submission case studies in Amsterdam, Dublin, Lisbon, Ljubljana and Sofia are confirmed, others will be possibly added in the course of the Action. Looking at a broad range of public places in these cities will contribute to a comprehensive overview.

The scientific programme pays attention to three mutually related areas: a) **public spaces** (their production and design and the way people use them), b) **ICT** (the opportunities, novelties, potential) and c) **social, behavioural and health research** (what is changing with the use of ICT). Especially the links between these areas will be focus of research. For each area different specific approaches and methods will be used- as described below in topic D.2. This list is however, not exhaustive and **CyberPark** will keep the set of research topics fairly open, in order to be able to incorporate new ideas resulting from the intense dialogue as well as information and knowledge

raised from exchange between the participants.
The analysis of case areas will be based on comparative cases looking at the current state of the art and supported by on-going research in each partner institution.
Therefore the scientific focus of the Action is defined by the following research tasks:
- Identification of examples of the intersection of ICT in public spaces, and their analysis,
- Identification of sustainable ideas, and the analysis of their scope,
- Identification of knowledge gaps and the development of novel approaches to close those gaps (opportunities arisen from COST actions, national and international research other European programmes),
- Identification of the role of ICT for the production of public spaces, and the way to introduce them into goals of European policies on technology, urban development and creative industries,
The Action is organised in 5 inter- and trans-disciplinary **Working Groups** (WG) for sharing knowledge and experiences, analysing, drawing lessons learnt and preparing the outcomes:

D.2 Scientific work plan methods and means

The research upon which **CyberPark** is based will investigate how and to which results the ICT intersect public spaces - in a broader view (from ICT devices and applications to urban planning and design to social behaviour. The Action will bring different expertise together and act as platform to make use of synergies from which to articulate views on the best future for the city and their public spaces. This focus calls for a deep engagement of the researchers involved, also to link/web their knowledge with different approaches.

The scientific work plan will be based on:

1. **Literature review** with regard to the tree areas mentioned in topic D1, encompassing evidences about the intersections of ICT and public spaces and their potential benefits,

2. Identification and selection of **already existing examples** of the connection of ICT with public space contexts, in order to analysis the effect and potential of the interactions,

3. Deployment of best-practice (wearable and fixed) sensing technologies as required to better understand the activities of people in public spaces. For example, the previous work of partners in sensing people using devices such as SenseCams,

4. Analysis of **Case studies** and the application of the Assessment Framework in practice. Also some *field experiments* will be undertaken in the case studies (e.g. in students' seminars, training schools or STSM) using new methodologies or those put in into a new context, e.g. data-gathering techniques, 24hour design workshops and events in which designers from various disciplines are brought together to reflect on the urban design practice. Both topics 2 and 4 will result in the selection of good practices,

5. Several **thematic workshops** and **working group meetings** to explore new opportunities and to combine different approaches. In these workshops the emerging findings of the research as well as the proposed approach to assessing the case studies will be widely discussed,

6. Tailored and structured **scientific exchanges** between research groups, e.g. STSM, training schools,

7. Applying an **Assessment Framework,** a comprehensive analytical agenda to assess the case studies. This framework, backed up by the literature review and research experiences of partners, seeks to establish a common ground to measure the impacts of the intersections of ICT & public spaces,

8. Networking activities and **exchange with external experts**, e.g.:
   8.1 *Local Symposia* - conceived as discussion and evaluation forums in case studies these symposia are open to local academic and professional community, municipal agents, planners, experts, decision makers, politicians, etc. They offer the chance to present and discuss the current state of work and intermediate results of the Action and gather a broad view on the local context. As an accompanying measure of the workshops these symposia will be also used as potential for dissemination (e.g. local public activities, press conferences, etc.)
   8.2 *Dissemination Conference* aiming at sharing theoretical approaches and research experiences as well as to strengthen networking and relationships within the research community,

9. **Methodology paper** – production and publication of a consistent methodology paper, which explains the proposed approach and the results of the assessments; and

10. **Theoretical and methodological report** – development of a report that brings together the results of the preceding stages.

Moreover, the Action will encourage the participation of young scientists (ESR) in research topics. A common scientific programme based on the topics and objectives described in section D.1 will be agreed upon by all participants. This includes the ESRs' participation in:
- Workshops and STSM with a broad range of experts to address specific areas,
- Training schools to educate a new generation of multidisciplinary researchers,
- In the Local Symposia, Dissemination Conference and Final Symposium.

The planned deliverables are:
D1 A **Theoretical and methodological report**,
D2 **Pool of good practices** containing a structured checklist and a photo library, addressing: a) scientific community by advancing compiled and structured knowledge; b) urban administrations by delivering supportive arguments for preparing or (re)shaping programmes and plans for attractive urban spaces, c) ICT users, d) model of good practice for international transdisciplinary collaboration between the humanities and sciences,
D3 **Learning module** representing an online set of key information to forward knowledge on processes and debates related to open spaces management, policies and strategies to be used in seminars and workshops,
D4 **White papers and journal publications**, this includes also the policy briefs and advocacy statements.

E. ORGANISATION

E.1 Coordination and organisation

This Action will be implemented over 4 years. The partnership is trans- and interdisciplinary. Partners have a strong record of collaboration in ICT development, research, design, lecturing, networks activities, organisation of international workshops and publications. These ensure broadly targeted and tailored dissemination activities.
Following the *Rules and Procedures for implementing COST Actions* **CyberPark** has a clear structure to enable the accomplishment of its objectives. The Action, carried out by a network of researchers from various COST countries, will be coordinated by the Management Committee (MC), whose chair and vice-chair will be elected at the kick-off meeting.
The tasks of the MC are:

- overall scientific coordination and evaluation of work progress,
- validation the work-plan,
- establishing the Working Groups and electing their leaders,
- supervising the accomplishment of COST and the Action rules and targets, e.g. gender balance, involvement of young researchers.

The MC will establish the **Executive Board**, to be composed by the MC chair, vice-chair and the working group leaders. The **Executive Board** will be responsible for the scientific management work. Its tasks are to:

- monitor the quality of work, set milestones and supervise their achievement;
- provide support for the organisation of MC meetings;
- facilitate and assure the transversal exchange among the working groups.

The **Executive Board** has dedicated meetings every 6 months or more frequently when needed. By maintaining regular periodic contacts by means of conference calls, videoconferences besides these meetings will ensure effective and continuous steering for the Action. The Action's Executive Board will report to the MC.

The WG leaders will be responsible for the coordination of activities within WG and report to the Action's Executive Board and MC.

Short Term Scientific Missions, coordinated by the **Executive Board** and committed to interdisciplinarity, gender balance and involvement of young scientists will be organised in order to enable further research in the case areas, to visit other interesting projects in-situ and to support a continuous transfer of knowledge and intensify cooperation with other networks on related topics.

The communication within the participants will be facilitated by means of an Action's internet portal and blog as an online forum to discuss and disseminate the Action. The leader of the **WG 5 - Networking & dissemination** will coordinate the dissemination activities while being assisted by the MC and the WG members. This WG will also be responsible for keeping the flow of communication among partners, updating the website and boosting network activities. If necessary a webmaster will be appointed. Involving ICT experts will ensure the use of ultimate technologies also for the electronic communication both within the Action and outside.

The structure of this Action is best suited to a COST Action compared to other EC funds because it requires diverse expertise which will be clustered around WGs research topics. All the participating partners possess required infrastructure and funding for the proposed research. Therefore funding is required only to facilitate the coordination of these activities.

Milestones and deliverables are described in the section F in conjunction with the description of a timetable.

E.2 Working Groups

The Action is organised in 5 transdisciplinary **working groups (WG)**, each one designed for gathering the **best research and information available,** collecting examples and experiences, sharing knowledge and experiences on different aspects of the interaction of ICT and public spaces, analysing those, drawing lessons learnt and preparing the outcomes.

WG 1 - Digital methods explores (recent and novel) ICT-tools to research the use of, and user-behaviour in public spaces. It will assess scientific, technical and sociological information (or opportunities) relevant for understanding the interweaving of people in (and with) public spaces. The purpose of this is, in part, to investigate the potential impacts and options for adding value to public spaces. Within this WG field experiments with new methodologies will be undertaken in case studies. The leading questions are: **How can we use ICT and new media technology to enhance our understanding of the uses and users of public spaces**? **What can we learn about public spaces through the use of new technologies or scraping public data that users of public spaces have produced?**

WG2 - Urban ethnography deals with cultural and sociological fieldwork using varying theoretical and methodological approaches. It will bring together knowledge about the use of new media technologies in public spaces from an ethnographic point of view and set up the understanding of the public spaces and human behaviour in the context of new media. In order to understand how best to connect technology and public spaces, we will observe both uses of technology within space, but also user-behaviour in that space not linked to technology. The purpose is to generate novel ideas about future ICT development to enhance and make more pleasurable the use of and user-behaviour in public spaces. It aims at widening branches outward in new directions towards enhancing the knowledge on the relations between users and their behaviour, new media and the spatial practice. The leading questions are: **What is known about the relationship between new media use and spatial practices? What do people want from public space? Does this differ by socioeconomic status, gender, age? What technological developments are most likely to enhance current user behaviour or develop new user behaviours?**

WG3 - Conceptual reflection provides room for reflection on both philosophical and methodological approaches and evidence informed practice to understand the complex relationships between contemporary values, habits and needs on one side, functions and potentials of public spaces for quality of life on the other, new media development and potentials and how it is or should be reflected in the urban fabric and place design. Its aim is to bring together knowledge about new ways of urban life people are tending or searching for in connection with new media and theoretical approaches of planning and design of urban public space. The leading questions are: **What can we learn from links between digital media in public spaces? Are new media practices changing the character, meaning, significance and functions of public spaces? What new possibilities new media offer for public spaces future development and design, and what are the problems and obstacles they are bringing?**

WG 4 - Creating CyberPark deals with design research and the nurturing of innovative and creative open space design practices. Using the outcomes from Working Groups 1, 2 and 3 this working group will bring together challenges the new media put to the test for urban and landscape designers, social, behavioural and health researchers, and will search for innovative answers for future development of urban open spaces. The leading questions are: **How do ICT challenges the design of public spaces? What could be the added value of the new technologies for the collective use of public spaces? How can designers operate on these conclusions in the production of public spaces? What is the contribution of various disciplines and how should they work together in this process?**

WG 5 – Networking & dissemination - as a think-tank this WG will be in charge of tailoring and transferring knowledge, organising workshops, young experts' platform, formulation of research perspectives and follow ups.

The organisation of work and coordination in these five working groups will allow focusing on specific scientific questions and research (as described in Section D). The annual programme and activities of the Action will also be prepared by the WGs and submitted for approval to MC. The WGs are strongly linked, transversal collaborations for sharing findings and short term scientific meetings will allow a feedback from the involved experts and researchers. Stakeholders and policy makers will be invited to share knowledge within WGs.

E.3 Liaison and interaction with other research programmes

As stated in chapter B.4 there are already contacts between **CyberPark** and existing research projects that partly touch the subjects of this COST Action. Further links with research organisations, city councils, governmental agencies and other projects related to this Action's issues and stakeholders will be systematically sought and established, through formal contacts, delegations to common bodies, or through the participation of common experts in the COST Action’s MC and WGs. Also the key players of other COST Actions with relevance to **CyberPark**'s topics will be

invited in workshops accordingly to exchange ideas and enhance the knowledge base of the whole research.
The planned liaisons with national initiatives in partner countries encompass the exchange of information, inviting advisors, speakers, etc thus facilitating the scientific exchanges. This task will be extensively elaborated within WG 5.

E.4 Gender balance and involvement of early-stage researchers

CyberPark will respect an appropriate gender balance in all its activities; the Management Committee will place this as a standard item on all its MC agendas. **CyberPark** will also be committed to considerably involve early-stage researchers. Also this item will also be placed as a standard item on all MC agendas.
Considerable responsibilities of the Action will be entrusted to Early Stage Researchers (ESR) to promote capacity building and personal qualifications in the field of ICT, place design, social, behavioural and health research. The instruments of Short-Term Scientific Missions (**STSM**) and **Training Schools,** as well as **field experiments** in the case study areas, will be used on this purpose.
In particular **STSMs** will be used to prepare the Actions' Workshops and the mentioned experiments to hold in the case studies. This will allow ESR to visit different scientific institutions and contact stakeholders (e. g. urban designers, ICT experts, ICT artists and policy makers) in a different country for 2 weeks, as well become acquainted with research methodologies and their assessment. Each STMS will elaborate a field report contributing to the Workshop. The reports will follow a structure to be developed by the ESR and by WG4 and approved by the Executive Board. The ESR will be hosted and supported by senior researchers from the visiting country.

F. TIMETABLE

The duration time of the Action will be 4 years. A preliminary time table is provided below and is subject to adjustments in order to allow the accomplishment of the Action's objectives. The time table will be discussed and further elaborated in the kick-off meeting, also aiming to assure an open and flexible character of the Action and to the partners. Corresponding changes are subject of decision by the MC.
The regularity, dates and locations of Action's events, i.e. meetings, STSM, training schools, and workshops will be decided by MC.

Structured activities will occur as follow:

Management Committee Meeting (MCM) will be held on a twice yearly basis – spring, autumn;

Executive Board will meet (virtually or face-to face every 6 months or when needed);

Thematic **Workshops -** organised by a single or more WGs will be held on a half-yearly basis (or if needed and finances allow more often) and will be held the best in conjunction with the **MCM**.

Training Schools will be held at least once per year, hosted in different cities (case studies) – fall.

Short term scientific mission (STSM) - on demand prior the approval by the MC.

Milestones:

Month 01: Kick-off meeting; adopting Action's programme for Year 1; establishing management and organisational structure (WGs, Executive Board, STSM)

Month 02: establishing electronic contact between all participants; dissemination material presenting the Action (flyer, slide show, poster),

Month 03: launching the Action's internet portal and blog; and the **Communication Strategy,** containing strategies and tailored papers and media information, and timeline,

Month 04: establishing an agenda for ESR and STMS,

Month 06: presenting the agenda and work plan for the case study analysis,

Month 12: defining Action's programme for Year 2,

Month 24: Mid-term meeting, and the **Dissemination Conference**

Month 24: identifying addressees: end users, decision makers and industrial partners,

Month 24-36: **Symposia in the case studies** with identified addressees,

Month 40: Development of a **legacy plan** for the time **after the end of the Action,**

Month 46: COST **Final Symposium** on ICT and Public Spaces to present and discuss the results to a broader academic, scientific and practitioners' community

Month 48: Submitting the Deliverables D1 and D2

G. ECONOMIC DIMENSION

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: BE, BG, DE, DK, FR, IE, IT, LV, NL, PL, PT, SI, UK. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at 52 Million € for the total duration of the Action. This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

H. DISSEMINATION PLAN

H.1 Who?

Corresponding to the wideness of the spectrum of Actions related issues the expected target audience will be a large one, whereas the following target groups for dissemination activities have been initially identified:

- Scientific community - working on urban development, public spaces, social behaviour, ICT features in communication,
- ICT experts - especially in the development of application devices,
- City councils, public bodies, regional government,
- Urban and landscape designers,
- Street furniture designers and producers,
- European-, national- and regional-level decision makers,
- Industry and services (e.g. Smartphones, Wi-Fi provision outdoors),
- Students (informatics, design, arts, urban planning, landscape architecture, etc.),
- Other COST Actions and Domains,
- Thematic national and international organisations (associations of landscape architects, urban planners, etc.),
- General public and media.

H.2 What?

The different target audiences identified in H.1 will be addressed by using following dissemination methods and (preliminary) contents:

- Organization of **Local Symposia, Dissemination Conference** and **Final Symposium** - these events address the scientific community ICT experts, urban designers, and decision makers, and aim to share theoretical approaches and research experiences as well as to strengthen networking and relationships, at local and international levels,
- **Internet portal and blog**, e.g. “cyberpark.net” composed of public and private domains. The public domain will contain 1) background & general information on the Action and partners; 2) the Action's blog as a discussion forum platform (to allow a broader exchange with users of ICT, especially young people); 3) news area, containing latest results, Action’s current status, informing and updating on events and new publications and 4) links to the home pages of partners and to other

generally accessible interesting websites. In the private domain - protected with a password - different web-conferencing platforms will be established to 1) make working documents accessible, 2) provide discussions and decision making forums (e. g for the Action's Executive Board, Working groups, etc.),

- Action's newsletter and links to partners' newsletter - at least twice per year, an electronic Newsletter will be prepared and widely distributed online. It will bring presentation of the Action, events, partners, describing existing and established examples of the relationship of ICT and public spaces, etc,
- Organising and participating to various events,
- Information set containing Action's leaflet and poster will be edited at the beginning of the Action and actualised in line with the progress of the Action,
- Publications and reports on indexed scientific journals,
- Training modules for educational and instructional purposes (e.g. videos, slides),
- Mass-media (TV, newspapers, popular science magazines) and Wikipedia,
- Social networking websites (Linkedin, Facebook, etc) especially to attract young scientists and users segment of general public.

H.3 How?

Involving ICT and communications experts in the network will enable **CyberPark** the use of ultimate technologies. To effect dissemination to broader audience, **CyberPark** on is oriented on active use of synergies, e.g. by organising Action's events in conjunction with other international and partner's events and actively supporting such events as initiator and co-organiser. The Action will further invite external experts in order to enhance collaboration with the institutions both from and outside of Europe. The combination of the:

- Action's website and blog,
- Presentation of Action's activities and results to the target groups at conferences and meetings,
- Organisation of dedicated events, like training schools, publications, white papers on Action's related topics, road mapping under participation of interested stakeholders will be a vital point for dissemination.

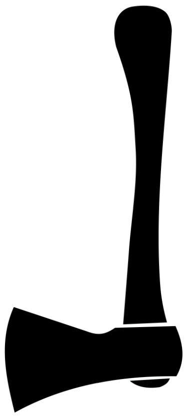
In order to keep the dissemination manageable and make use the synergies there will be a working group (WG 5) dedicated to this topic. Within this WG not only the dissemination strategy will be develop but also a legacy plan containing follow ups and activities for the time after the Action.

Appendix B

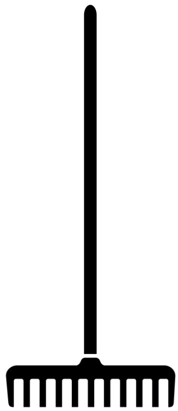
Stimuli used in experiments

Part 1: ax (normal orientation), rake (normal orientation), shovel (normal orientation), broom (normal orientation).

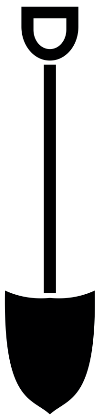
15



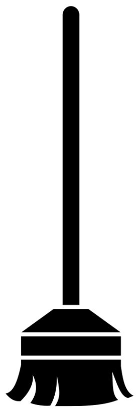
2



3

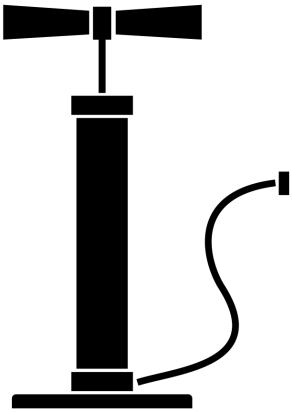


4

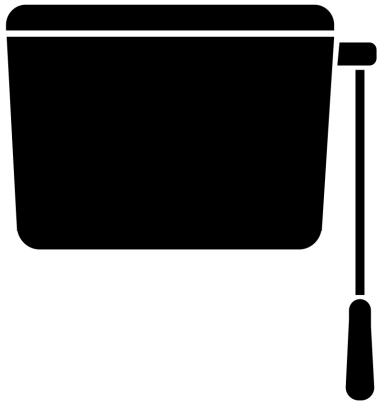


Part 2: pump (normal orientation), flush (normal orientation), stamp (normal orientation), plunger (normal orientation).

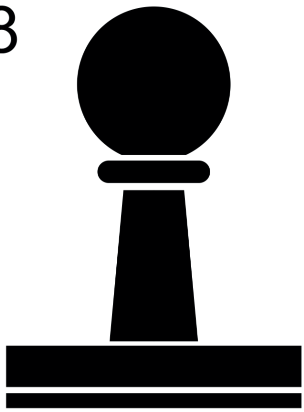
13



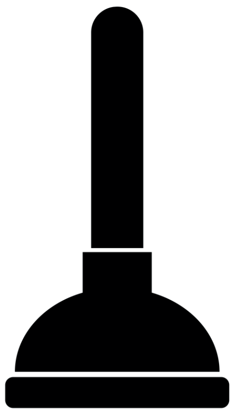
16



18

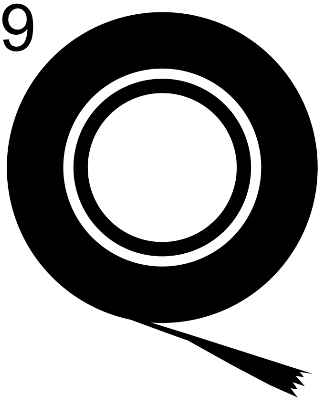


14

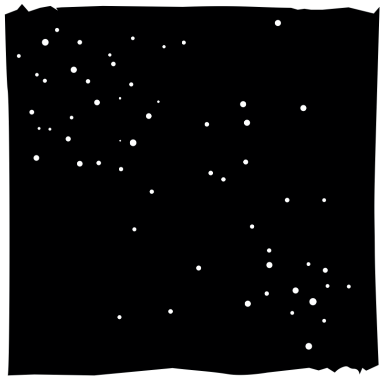


Part 3: tape (normal orientation), sandpaper (normal orientation), spray (right-hander orientation), hammer (left-handed orientation).

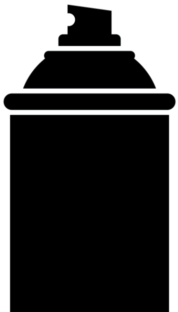
19



10



17



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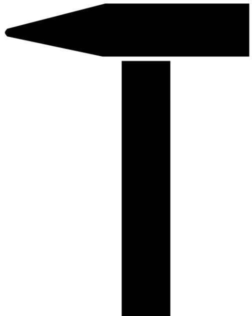
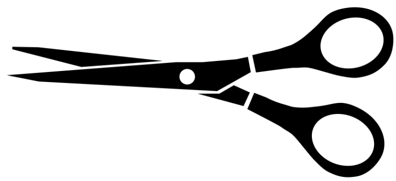


Part 4: pen (right-hander orientation), scissors (right-hander orientation), pencil (right-hander orientation), file (right-hander orientation).

1

6



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Part 5: knife (left-handed orientation), sharpener (left-handed orientation), saw (left-handed orientation), stapler (left-handed orientation).

7

9

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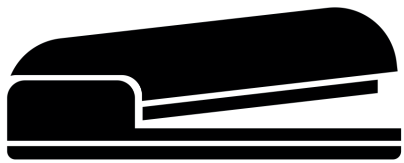
20



Appendix C

Combinations of stimuli

Part 1: Sternberg tasks (pictures numbers: see Appendix B; in black: repeated stimulus)

	Block 1	Block 2	Block 3	Block 4	Block 5	Block 6	Block 7	Block 8
Screen 1	"Start"	"Start"	"Start"	"Start"	"Start"	"Start"	"Start"	"Start"
Screen 2	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)
Screen 3	Picture 1 (217 ms)	Picture 8 (217 ms)	Picture 15 (217 ms)	Picture 18 (217 ms)	Picture 13 (217 ms)	Picture 18 (217 ms)	Picture 20 (217 ms)	Picture 9 (217 ms)
Screen 4	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)
Screen 5	Picture 2 (217 ms)	Picture 9 (217 ms)	Picture 3 (217 ms)	Picture 2 (217 ms)	Picture 1 (217 ms)	Picture 14 (217 ms)	Picture 2 (217 ms)	Picture 19 (217 ms)
Screen 6	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)
Screen 7	Picture 3 (217 ms)	Picture 10 (217 ms)	Picture 16 (217 ms)	Picture 19 (217 ms)	Picture 8 (217 ms)	Picture 19 (217 ms)	Picture 15 (217 ms)	Picture 11 (217 ms)
Screen 8	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)
Screen 9	Picture 4 (217 ms)	Picture 11 (217 ms)	Picture 5 (217 ms)	Picture 4 (217 ms)	Picture 20 (217 ms)	Picture 17 (217 ms)	Picture 3 (217 ms)	Picture 18 (217 ms)
Screen 10	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)

	Block 1	Block 2	Block 3	Block 4	Block 5	Block 6	Block 7	Block 8
Screen 11	Picture 5 (217 ms)	Picture 12 (217 ms)	Picture 17 (217 ms)	Picture 20 (217 ms)	Picture 15 (217 ms)	Picture 16 (217 ms)	Picture 12 (217 ms)	Picture 14 (217 ms)
Screen 12	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)
Screen 13	Picture 6 (217 ms)	Picture 13 (217 ms)	Picture 10 (217 ms)	Picture 9 (217 ms)	Picture 7 (217 ms)	Picture 6 (217 ms)	Picture 8 (217 ms)	Picture 16 (217 ms)
Screen 14	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)	"+" (1000 ms)
Screen 15	Picture 7 (217 ms)	Picture 14 (217 ms)	Picture 12 (217 ms)	Picture 11 (217 ms)	Picture 10 (217 ms)	Picture 4 (217 ms)	Picture 6 (217 ms)	Picture 17 (217 ms)
Screen 16	Mask (1000 ms)	Mask (1000 ms)	Mask (1000 ms)	Mask (1000 ms)	Mask (1000 ms)	Mask (1000 ms)	Mask (1000 ms)	Mask (1000 ms)
Screen 17	Picture 4 "Yes or No"	Picture 11 "Yes or No"	Picture 6 "Yes or No"	Picture 7 "Yes or No"	Picture 1 "Yes or No"	Picture 13 "Yes or No"	Picture 5 "Yes or No"	Picture 19 "Yes or No"
Screen 18	Blocks list	Blocks list	Blocks list	Blocks list	Blocks list	Blocks list	Blocks list	Blocks list

Part 2: two-back tasks (pictures numbers: see Appendix B; in black: repeated stimulus)

	Block 1	Block 2	Block 3	Block 4
Screen 1	"Start"	"Start"	"Start"	"Start"
Screen 2	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 3	Picture 1 (217 ms)	Picture 11 (217 ms)	Picture 5 (217 ms)	Picture 14 (217 ms)
Screen 4	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 5	Picture 2 (217 ms)	Picture 1 (217 ms)	Picture 10 (217 ms)	Picture 19 (217 ms)
Screen 6	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 7	Picture 3 (217 ms)	Picture 12 (217 ms)	Picture 6 (217 ms)	Picture 14 (217 ms)
Screen 8	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 9	Picture 4 (217 ms)	Picture 2 (217 ms)	Picture 11 (217 ms)	Picture 20 (217 ms)
Screen 10	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)

	Block 1	Block 2	Block 3	Block 4
Screen 11	Picture 5 (217 ms)	Picture 13 (217 ms)	Picture 6 (217 ms)	Picture 1 (217 ms)
Screen 12	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 13	Picture 6 (217 ms)	Picture 3 (217 ms)	Picture 7 (217 ms)	Picture 2 (217 ms)
Screen 14	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 15	Picture 5 (217 ms)	Picture 14 (217 ms)	Picture 12 (217 ms)	Picture 3 (217 ms)
Screen 16	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 17	Picture 7 (217 ms)	Picture 3 (217 ms)	Picture 8 (217 ms)	Picture 7 (217 ms)
Screen 18	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 19	Picture 8 (217 ms)	Picture 4 (217 ms)	Picture 13 (217 ms)	Picture 18 (217 ms)
Screen 20	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 21	Picture 9 (217 ms)	Picture 15 (217 ms)	Picture 9 (217 ms)	Picture 7 (217 ms)

	Block 1	Block 2	Block 3	Block 4
Screen 22	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 23	Picture 10 (217 ms)	Picture 5 (217 ms)	Picture 14 (217 ms)	Picture 4 (217 ms)
Screen 24	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 25	Picture 11 (217 ms)	Picture 15 (217 ms)	Picture 9 (217 ms)	Picture 10 (217 ms)
Screen 26	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 27	Picture 10 (217 ms)	Picture 17 (217 ms)	Picture 1 (217 ms)	Picture 13 (217 ms)
Screen 28	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 29	Picture 12 (217 ms)	Picture 6 (217 ms)	Picture 15 (217 ms)	Picture 12 (217 ms)
Screen 30	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 31	Picture 13 (217 ms)	Picture 17 (217 ms)	Picture 1 (217 ms)	Picture 17 (217 ms)
Screen 32	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)

	Block 1	Block 2	Block 3	Block 4
Screen 33	Picture 14 (217 ms)	Picture 16 (217 ms)	Picture 2 (217 ms)	Picture 12 (217 ms)
Screen 34	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 35	Picture 13 (217 ms)	Picture 7 (217 ms)	Picture 16 (217 ms)	Picture 16 (217 ms)
Screen 36	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 37	Picture 15 (217 ms)	Picture 18 (217 ms)	Picture 2 (217 ms)	Picture 11 (217 ms)
Screen 38	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 39	Picture 16 (217 ms)	Picture 8 (217 ms)	Picture 3 (217 ms)	Picture 15 (217 ms)
	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 40	Picture 17 (217 ms)	Picture 18 (217 ms)	Picture 17 (217 ms)	Picture 11 (217 ms)
Screen 41	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 42	Picture 16 (217 ms)	Picture 19 (217 ms)	Picture 4 (217 ms)	Picture 5 (217 ms)

	Block 1	Block 2	Block 3	Block 4
Screen 43	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 44	Picture 18 (217 ms)	Picture 20 (217 ms)	Picture 18 (217 ms)	Picture 8 (217 ms)
Screen 45	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 46	Picture 19 (217 ms)	Picture 9 (217 ms)	Picture 4 (217 ms)	Picture 6 (217 ms)
Screen 47	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 48	Picture 20 (217 ms)	Picture 20 (217 ms)	Picture 19 (217 ms)	Picture 8 (217 ms)
Screen 49	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 50	Picture 19 (217 ms)	Picture 10 (217 ms)	Picture 20 (217 ms)	Picture 9 (217 ms)
Screen 51	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)	"+" (2500 ms)
Screen 52	Blocks list	Blocks list	Blocks list	Blocks list

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Michal Klichowski is one of the most talented young researchers in Poland [...]. Michal Klichowski's publications represent a high-quality level; they are read and cited [...]. His papers open new problem fields for educational sciences; they are characterized by "intellectual freshness", openness and interdisciplinarity, as well as the ability to combining theoretical analysis with empirical studies. All of these positive comments apply also to Michal Klichowski's latest book. [...] This book is of great value; it constitutes the original contribution of the Author not only to the problem being analyzed but also to the contemporary social science. In this book Michal Klichowski confirms his theoretical and empirical competences [...] and shows that he has a clear academic identity.

Prof. Zbyszko Melosik
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Michal Klichowski's work opens a fascinating and stimulating read for scholars and researchers […]. This highly illuminating book marks a significant stage in growing our understanding of how digital technology development is affecting people's relations among themselves and with their environment […]. The research made for his book provides on the side, evidences that multidisciplinarity and interdisciplinarity going over the edge of single disciplines meld ideas and boost cross-pollination, paving the way for advancing comprehensive knowledge and opening new research prospects […]. This book is a step forwards to achieving the aims of CyberParks [...]. Building digital bridges calls for experts who can face the challenge of a continually evolving society, what Michal Klichowski mastered perfectly with his pioneering book.

Prof. Carlos Smaniotto Costa
Lusofona University of Humanities and Technologies

Michal Klichowski has written an excellent text about information technology in both formal and non-formal education. […] the book synthesizes current knowledge (ideas, theories and empirical research, from a critical point of view) in "technology enhanced" education. […] this reading has just inspired me to try to implement some of the ideas discussed in the book on the campus of my own university… It's almost impossible to give a better example of an influence of a book on its reader […]. The studies are clearly explained and relevant to the thesis of the book: we need a "smart education system" if we want that our schools become more relevant for current and future generations.

Prof. Vitor Duarte Teodoro
Nova University of Lisbon

This book offers an important perspective to the current research and debates around livable and "smart" cities, and the active role of citizens in them. By approaching questions of "smart citizenship" from the angle of pedagogics and learning, the book systematically contributes to our thinking how a civic "smartness" might actually be developed.

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