1 The Need for Improved Learning Efficacy in a World of Digitalization

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1.1 Abstract

Digitalization is rapidly spreading across countries and industries affecting all social classes. Digitalization is changing the way of how people work and how they live. The digital transformation leads to new roles, which demand today's workforce to acquire new skills. Workers and employees of all kinds of occupations and professions are potentially affected by digitalization. Organizations are struggling to find skilled workforce. To overcome these challenges, organizations need to equip themselves with the capability of effective learning and so do individuals. Learning capabilities become a cornerstone, both from an organizational perspective as well as from an individual perspective.

While the speed of technological change is explosively accelerating the question arises how long learning curves can be transformed into shorter learning curves. Two aspects are being addressed which potentially improve the efficacy of learning: educational neurotechnology and educational quality management systems. Current developments of brain-machine interfaces and their potentials are described as well as the potential benefits of educational quality management systems. Both approaches, while inherently different, can have a positive impact on learning efficacy.

Keywords: learning, educational neurotechnology, educational quality management systems

1.2 Introduction

The digital evolution has occurred quickly and is affecting about every aspect of modern life. It is strongly impacting knowledge-based societies and economies requiring new skills and an increased focus on our ability to learn. According to directions from OECD (Organization for Economic Cooperation and Development) analyses "…learning is central in knowledge-based societies and economies, consequently reforms of the education systems should focus more strongly on learning itself rather than simply changing structures" (EDU/CERI/CD, 2008). Since digitalization is already deeply embedded in learning processes continuous upgrading of learning and teaching related activities is fundamental. This refers to both, organizations or institutions as well as individuals.

Organizations and institutions of all kinds may benefit from national or European policy initiatives, from combining all EU's current schemes of education and training (Erasmus Plus), from the Bologna process by promoting intergovernmental cooperation in the field of higher education and implementing a system of quality assurance to strengthen the quality and relevance of learning and teaching, from stakeholder collaboration, from technology and infrastructure, and from educational quality management systems.

Individuals may benefit from new approaches to learning processes, from valorization of non-formal and informal learning, from life-long learning, everywhere and anytime learning, e-learning, and from learning-analytics based individual learning paths. Today, personalizing learning is of growing prominence. Two decades ago, according to (OECD-CERI, 1999) too little was known about brain function to reliably infer a rule that would enable us to understand intelligence and, thus, human cognition and behavior. A project on "Learning Sciences and Brain Research" was launched 1999 by OECD's CERI (Centre for Educational Research and Innovation) Governing Board. Since then, the explosion of knowledge about the brain and the nature of learning helped identifying effective solutions. Today massive neuroscientific

research into the brain itself is conducted, supported by the European Human Brain Project[1] and by the US-led BRAIN[2] (Brain Research through Advancing Innovative Neurotechnologies). Both, neurosciences as well as quality assurance measures aim to improve learning efficiency. Figure 1 illustrates the impacts on individual learning and the impacts on institutional learning.

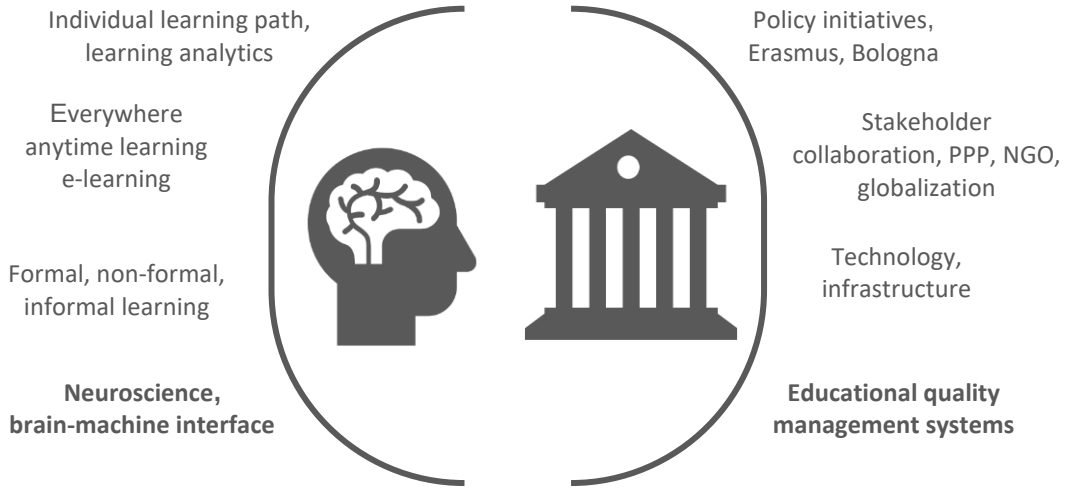

Figure 1: *Impacts on individual learning and impacts on institutional learning.*

The following chapters describe the individual's and the institution's learning approaches by means of neuroscience and brain-machine interfaces on the one hand, and educational quality management systems on the other hand.

1.3 Neuroscience, Brain-Machine Interface

Already at an early stage the study of the brain revealed many insights, like the effects of emotional states on learning and memory, like the necessity of learning to learn skills, like the plasticity of the brain showing that individual characteristics are far from fixed, like "one-size-fits-all" approaches being ill-adapted to individuals' needs and to the knowledge society at large, and like many more psychoeducational insights. Neurotechnologies can allow researchers and educators to have new ways to represent and see the processes involved in the brain during different situations of interest. In some way this is equivalent to start opening the black box of the brain to reveal individual differences, tendencies and in developing long-term processes, and start to know about the way brain uses information to solve problems in learning tasks (Diaz et al., 2012).

But learning is one of the most complex processes underlying human capabilities. Neurosciences try to understand and manipulate these processes. Neuroelectrical activity was detected first in 1924, in the 1970s DARPA (Defense Advanced Research Projects Agency) started to explore brain communication and evidence was provided that brain signals could be used to interact with external devices. Since then, brain-machine interfaces (BMI), systems that allow communication between the brain and various machines by measuring brain signals (electrical potential, magnetic field, blood flow density) non-invasively, semi-invasively or invasively, are applied to a variety of tasks. Those tasks include but are not limited to neurofeedback and learning. In 1999 it was shown that BMI could be used for limited hand movement, in 2003 the first BMI game was demonstrated, in 2008 voiceless phone calls were demonstrated, in 2014 direct brain-to-brain communication over the internet was achieved. In 2017 Facebook CEO Mark Zuckerberg announced: "*We are working on a system that will let you type straight from your brain. … Technology is going to have to get lot more advanced*

[1] https://www.humanbrainproject.eu/en/
[2] https://www.braininitiative.org/

before we can share a pure thought or feeling, but this is a first step." (NeuroTechX 2019). Once such advanced applications enable solid direct data transfer between the brain and any electronic device the human cognitive performance will change fundamentally.

Renowned research facilities, tech giants and start-ups are heavily involved in research and development of tools and applications which allow for advanced forms of human computer interaction:

- The Neural Engineering System Design program by DARPA[3] seeks to develop high-resolution neurotechnology. According to DARPA the focus of the program is development of advanced neural interfaces that provide high signal resolution, speed, and volume data transfer between the brain and electronics, serving as a translator for the electrochemical language used by neurons in the brain and the ones and zeros that constitute the language of information technology.
- The Targeted Neuroplasticity Training program [4] by DARPA supports improved, accelerated training of military personnel in multifaceted and complex tasks. According to DARPA it focuses on cognitive skills training by precise activation of peripheral nerves through stimulation by release of brain chemicals. In that way the synaptic plasticity is regulated in order to improve brain function during learning.
- BMI interfaces by the start-up company Paradromics[5] intend to increase the data transmission rate between brains and computers. An implantable chip records and stimulates electrical activity in the brain.
- Ultra-high bandwidth brain-machine interfaces to connect humans to computers are announced by Neuralink[6]. An integrated brain-machine interface platform has been developed (Musk, 2019).
- BrainCo[7] is a product of the Harvard Innovation Lab offering wearable headbands for education, fitness, and mind-controlled games. It aims to aid in the improvement of attention level and to help those affected with focus issues and learning difficulties.
- EMOTIV's mobile EEG headset [8] monitors brain responses (excitement, interest, stress, engagement, attention, meditation) in real time, thus allowing for achieving peak mental performance

These examples are intended to illustrate the current state of R&D. In the medium to long term, neurotechnologies will fundamentally change our understanding and our ability to communicate and to learn.

1.4 Educational Quality Management Systems

Educational Quality Management Systems aim at achieving quality goals in education through planning and monitoring. Quality management systems (QMS) started to surface about one hundred years ago. In short, the purpose of quality management is about customer satisfaction. Management theories are derived from industries, they have been applied to education not until decades later. Ever since there is an ongoing debate on the applicability of quality management principles, methodologies and tools to the education sector. Nevertheless, QMSs are widely used in Europe in higher education and in further education. There is a considerable variety of QMSs in German-speaking countries. The German Federal Institute for Vocational Education and Training and the German Institute for Adult Education, Leibnitz-Zentrum für Lebenslanges Lernen e.V., surveyed German training providers (n=1755) to

[3] https://www.darpa.mil/program/neural-engineering-system-design
[4] https://www.darpa.mil/program/targeted-neuroplasticity-training
[5] https://paradromics.com/
[6] https://neuralink.com/
[7] https://www.cbinsights.com/company/brainrobotics
[8] https://www.emotiv.com/

determine the distribution of QMSs in use in continuing education and analyzed their effectiveness attributions (Ambos 2017). According to this survey, the majority of continuing education providers had at least one QMS in use by 2017. The QMS most frequently used by CVET providers in 2017 were the longstanding DIN EN ISO 9000ff, LQW (Learner-Oriented Quality Testing in CVET) and EFQM (European Foundation for Quality Management). Later, the International Standard Organization ISO published another standard, ISO 29990, to specifically provide a common reference for learning service providers. The newest educational QMS standard ISO 21001 is intended to be useful to all kinds of educational providers, from kindergarten to higher education, vocational training centres and e-learning services and focuses on the specific interaction between an educational organization, the learner, customers and other relevant interested parties.

According to the study mentioned above, those providers who worked without a QMS (20% of the respondents) argued that no QMS was required for achieving good quality. But in general, the institutions surveyed attested that the QMS had rather positive effects. It is further stated that, with regard to organization, an improvement in organizational processes (90%) and an increase in transparency (85%) are being attested to; with regard to offer quality, an improvement in teaching/learning processes (64%), a professionalization of pedagogical work (59%) and an increase in participant satisfaction (56%); with regard to the market, an increase in costs (61%), a strengthening of the market position (56%) and higher customer loyalty (38%) (See Fig.2).

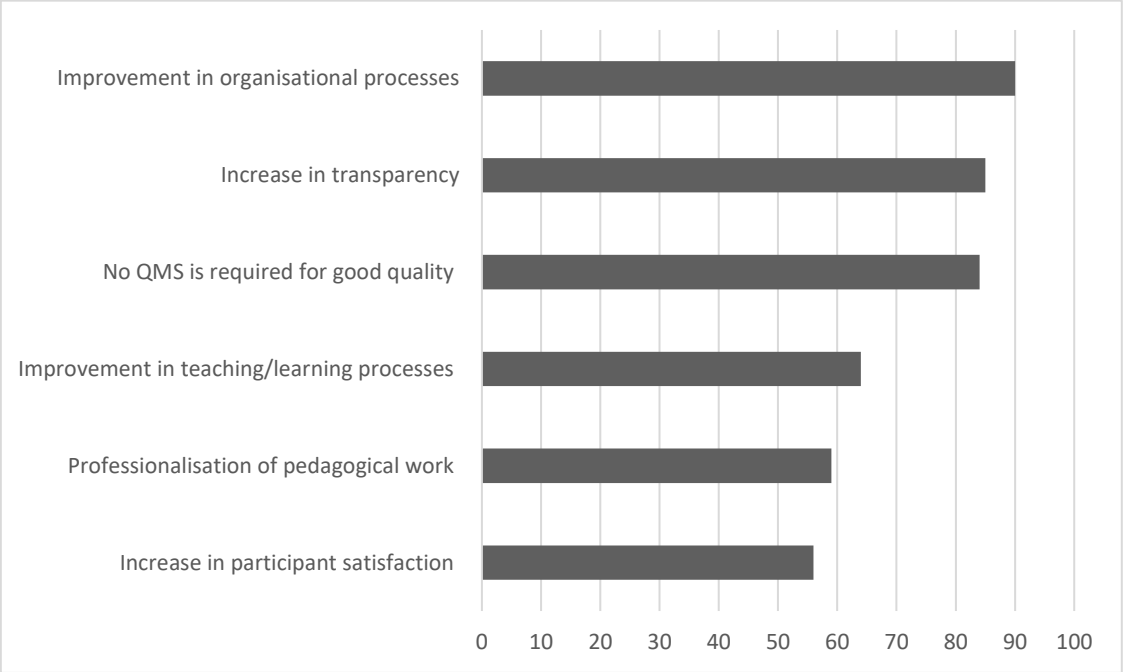

Figure. 2: *Responds of German providers of vocational training (n=1755).*

Although numerous QM models and quality development procedures have been established along with a flourishing market of quality certifications and agencies in the field of continuing education over the past 20 years, evaluations of effects on learning outcomes as such have come to rather sobering conclusions. According to the study by the Friedrich-Ebert-Stiftung: "*It seems that the effect of quality procedures often refers successfully to the surface and organisational level, but hardly or not reaches the core of continuing education at the level of teaching and learning processes*" (Käpplinger 2017).

The concept of education quality is certainly multidimensional, addressing features of the educational system, organizational frameworks, social and economic requirements, and qualification characteristics of learners. Educational QMS have contributed considerably to

improve sharing and transferring knowledge. According to (Michalska-Cwiek, 2009) the process of implementing QMS has a significant influence on improving the quality of education.

1.5 Conclusions

The digital transformation of the economy and society can only succeed with improved learning efficacy. Both, organizations and individuals need to equip themselves with enhanced capability of effective learning. Educational quality management systems, which have been around for about two decades, play an important role when it comes to support the acquisition and development of competence through teaching, learning or research. Quality in education is required in order for communities and societies to prosper.

The process of learning from an individual's point of view has also undergone a new development about two decades ago since the advent of e-learning. However, real progress in learning can only be expected with the application of neurotechnology. Interfaces between brain and machine promise an unprecedented expansion of cognitive abilities. Let us assume that improved learning effectiveness is accompanied by a higher degree of maturity and wisdom.

1.6 References

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