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Guest Editor's Foreword

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What does education, industry, business and society need for a viable and successful future? The actual mega-trend of digitization and linked issues such as data management and privacy or easiness of access to technologies have a strong impact on what indeed is needed. In the context of digitization also the pressure for agility increases, i.e. the capability to adapt quickly and adequately to changes in e.g. the market or society. Organizations as well as individuals have to understand themselves as stadily learning entities, respectively persons, and have to act accordingly. Learning and knowledge are becoming again more important because they are the base to deal successfully with these challenges. Accordingly, papers in this Special Issue address challenges in a field which I might call management and role of data and learning in the era of digitization.

The authors of the first paper introduce artificial intelligence to the emotional intelligence model. The blend of artificial and emotional intelligence shall support strategic decisions in organizations. The relevance of the model is illustrated by using the US-retail giant Best Buy as an example. The second paper considers the unequal distribution of digital technologies and its impact on economic performance across countries (EU and non-EU). The basic assumption is that digital technologies lead to digital dividends which impact economic growth positively. In paper three the concept of schools as learning organizations in the Romanian educational system is discussed on a theoretical level. The authors argue that such a concept is needed due to an environment shaped by constant changes in society, technologies and trade. On the basis of a structural equation modelling and the bootstrapping method paper no. 4 examines the mediating role of skills application in the relationship between learning and continuous improvement in a knowledge-intensive company. The author's aim is to contribute to the understanding of the effects of investments in training and development in institutions. The fifth paper focuses on the construction sector. It states that the life-cycle of building objects, i.e. the needs during design, construction and the use-phase are not acknowledged effectively today, a bigger picture is missing. The paper therefore aims to form the pre-requisites for managing construction object related data adequately and to consider literature to gain the bigger picture and more effectiveness. The sixth paper considers the European General Protection Regulation (GDPR) in Higher Education Insititutions (HEIs). These institutions have to reassess the processing of personal data. Based on literature and design science guidelines the authors provide consolidated recommendations and requirements to GDPR as well as an instrument to help HEIs to raise their GDPR aswareness.

All submitted and selected papers of this Special Issue were presented at the MakeLearn & TIIM 2019 international conference held in Piran (Slovenia) on 15–17 May. They have undergone a double-blind review process and two rounds of revision. I would like to thank to all authors and especially also to all the reviewers for their constructive and focussed efforts in this process which enabled and supported the advancement of the papers. Moreover, I want to thank the Editor-in-Chief, Kristijan Breznik, for the opportunity to be a Guest Editor and for his trust and guidance.

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From Artificial to Emotional Intelligence: Integrating Five Types of Intelligence to Achieve Organizational Excellence

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Decision Support Systems have significance, as today firms turn to big data, machine learning, and artificial intelligence to guide strategy development and improve organizational performance. However, technology is not enough; human intelligence is necessary. This paper introduces Artificial Intelligence to the Emotional Intelligence Model, which blends technology and humanity to support strategic decision-making. Such a model builds on the Data-Information-Knowledge-Wisdom hierarchy and knowledge management to integrate five types of intelligence. The consumer electronics retail giant Best Buy is used as a case to illustrate the relevance of the model. The presented framework provides a powerful, mental model to support organizational strategists and business executives.

Keywords: DIKW hierarchy, knowledge management, tacit knowledge, artificial intelligence, business intelligence, competitive intelligence, decision intelligence, emotional intelligence

Introduction

Rapid advances in information and communication technologies (ICT) have presented established business to consumer (B2C) retail firms with both opportunities and threats. Over the past decade, one major, ICT-driven trend has been the rise of online retailing and attendant changes in consumer

* The authors' affiliation with The MITRE Corporation is provided for identification purposes only, and is not intended to convey or imply MITRE's concurrence with, or support for, the positions, opinions or viewpoints expressed by the author.

shopping and purchasing habits that challenge the traditional, brick-and-mortar model long followed by leading B2C companies. As successful online retailers like Amazon began to inexorably eat away the market share of traditional, brick-and-mortar retail chain stores, many traditional B2C firms found themselves unable to come up with a strategic response to the price, variety, selection, and convenience advantages of online shopping. Many such firms have suffered sizeable losses in market share, and some have either declared bankruptcy or have been projected to do so in the near future: in October 2018, after more than a century of existence, once-dominant US retailer Sears declared bankruptcy (Wahba, 2018) and, by December 2018, industry experts were predicting that another industry giant, JCPenney, was not far behind (Martin, 2018).

Just a few short years ago, computer-electronics retailer Best Buy was in a comparable state of decline. Chagrined Best Buy store managers increasingly found themselves standing by helplessly as visiting customers would engage in a practice known as 'showrooming,' or physically examining new products in a store but then going home to purchase the item, more cheaply, from an online vendor like Amazon (Bariso, 2019). Like so many of its industry peers, Best Buy found itself in serious trouble, and corporate executives knew they needed to come up with a strategic response, and fast, if the company hoped to avoid the financial death-spiral being experienced by some of its peer competitors in the industry.

For commercial firms faced with a significantly-changing operating environment, the difference between bankruptcy and continued profitability is adaptability, and adaptability requires sound strategy stemming from wise and informed decision-making. While erstwhile 'blue chip' firms like Sears and JCPenney failed to adapt, the US-based consumer electronics retail giant Best Buy not only staved off disaster but has reversed its decline and even prospered. This article uses Best Buy's strategic response to its described predicament as a representative example to examine how organizational leaders can draw upon a mix of technological and human cognitive resources to address even the most seemingly intractable of problems to come up with creative, workable solutions. The A2E (Artificial Intelligence to Emotional Intelligence) Integrated Intelligence Model introduced in this article encompasses five different, but complementary, types of intelligence: (1) Artificial Intelligence (AI), (2) Business Intelligence (BI), (3) Competitive Intelligence (CI), (4) Decision Intelligence (DI), and (5) Emotional Intelligence (EI).

Each type of intelligence is briefly described, as is the way executives faced with a challenge (like the one confronting Best Buy) could leverage that particular type of intelligence to support development of an informed, sound, and successful strategy. While each of the five types of intelligence can be a useful tool in and of itself to address a specific dimension of a problem, the most effective approach is to use them collectively to solve a problem as a whole. To that end, this article builds upon the well-known Data-Information-Knowledge-Wisdom (DIKW) hierarchy, coupled with such core knowledge management concepts as tacit and explicit knowledge, knowledge discovery, creation, and application, to integrate the five distinctive types of intelligence into a coherent, unified, and elegant conceptual framework. This simple, yet powerful framework can serve as a mental model to help strategists and executives conceptualize an effective approach to problem-solving. This paper used Best Buy as an illustrative case study to demonstrate the relevance and usefulness of this model in strategic thinking and organizational management.

DIKW Hierarchy & Knowledge Management

The DIKW hierarchy, also known as the wisdom pyramid, is a commonly-used construct in information systems research (Ackoff, 1989; Davenport & Prusak, 1998; Zeleny, 2006; Rowley, 2007; Skovira, 2007). The DIKW hierarchy represents the full spectrum and cumulative nature of human experience. From an ontological perspective, DIKW represents four different types of experience: *Data* are the most primitive type, which result from observing events, environments, and humans via our senses and modern sensors; *information* represents patterns extracted or abstracted from the observational data, and helps humans understand *what* things are; *knowledge* represents the sensemaking of information in the personal and social context, and helps humans understand *how* things are; *wisdom* is at the pinnacle of the hierarchy, and represents the human beliefs, purposes, values, and judgement, which helps humans understand *why* things are. From an epistemological perspective, DIKW represents the increasing level of human understanding through the incremental process of discovering, creating, and applying human knowledge, and helps to better understand human decision-making.

Wang (2018) proposed a conceptual data analytics process model using the wisdom pyramid as the overarching structure. The model described data analytics as a three-phase process as shown in Figure 1. Phase 1 is the *knowledge discovery* phase (from data to information), where information is extracted from data using such information technology as data management and machine learning. Phase 2 is the *knowledge creation* phase (from information to knowledge), in which information is contextualized through human interpretation and collaboration to create new knowledge. Phase 3 is the *knowledge application* phase (from knowledge to wisdom), in which the discovered and created knowledge is applied to make informed decisions, improve human conditions, and solve human problems.

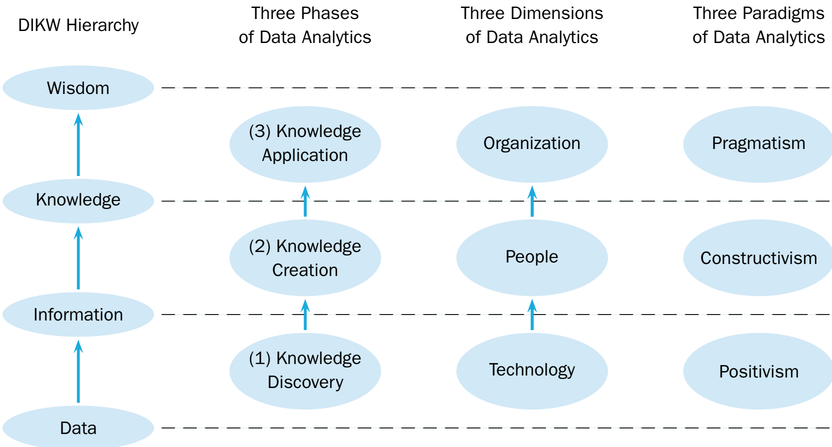


Figure 1 Data Analytics as a Three-Phase Process

Five Types of Intelligence

Artificial Intelligence (AI)

The core difference between an 'intelligent' system empowered by AI and a 'dumb' machine is the ability to learn from experiences, improve over time, and apply that learning to new activities (Cognilytica, 2018). With AI technology, knowledge management (KM) is able to move to a higher level of the DIKW pyramid with much greater value. The Machine Learning (ML) part of AI provides a bridge between information and knowledge. The three types of ML, (1) supervised learning; (2) unsupervised learning; and (3) reinforcement learning, map each type to a different level of the DIKW model. Supervised learning is good for executing a particular task, i.e., it is 'task-driven' (Cognilytica, 2018). It is good for performing classification and regression-type algorithms where the goal is to find a relationship between inputs and outputs. Unsupervised learning is used in a situation where the focus is on the data and the discovery of a higher order of information, i.e., it is 'data-driven' (Cognilytica, 2018). Here, unsupervised learning is widely used in clustering where large amount of data can be organized based on observed patterns. Reinforcement learning works well in areas where any goal- and decision-oriented experiences are relevant, i.e., it is 'goal-driven' (Cognilytica, 2018). This last type of ML enables a machine to learn 'a series of actions by maximizing a "reward function"' where learning is done through 'trial and error' (Cognilytica, 2018).

The dawn of AI technology has given hope to humans to leverage AI in areas where humans have shortcomings, and to expand humans' capabilities in areas where AI has deficiencies. The resulting outcome should be a world where 'augmented intelligence' persists – the combination of the best of the humans and AI worlds. Thus, wisdom will persist and prevail at the pinnacle of the DIKW model.

Business Intelligence (BI)

In the commercial world, the three related disciplines of business intelligence (BI), competitive intelligence (CI), and knowledge management (KM) are commonly referred to as *commercial intelligence* (Hoffman, 2018) or *strategic intelligence* (Kruger, 2010). While all three disciplines have benefited from advances in ICT to support informed decision-making, how they do so, and for what purposes, differ in significant ways.

BI is a commercial intelligence discipline that supports informed decision-making by mining and analyzing the ever-increasing types and quantities of data generated and stored by a business in the course of its normal operations. 'BI goes from the process of collecting large amounts of data, its analysis, and consequent production of reports that summarize the essence of actions on the business, which will assist the managers in the decision making of the day-to-day business' (Guarda et al., 2016, p. 1). 'Business intelligence (BI) provides decision-makers with data, information, or knowledge to address decisions about problems specific to the individual decision-maker needs, and that can be "rolled up" to support broader organizational level decision-making' (Visinescu, Jones, & Sidorova, 2017, p. 58).

Most information analyzed by BI practitioners consists of data that is both generated and held by the company itself. In most cases, that data is available, accessible, reliable, and voluminous. BI professionals use automated systems and specialized software to analyze data for the purpose of engaging in descriptive, predictive, or prescriptive analysis. BI generally involves identifying 'patterns, trends, rules, and relationships from volumes of information which are too large to be processed by human analysis alone' (Alnoukari & Hanano, 2017, p. 6). Increasingly supported by 'artificial intelligence, machine learning, database systems and statistics' (Mishra, Hazra, Tarannum, & Kumar, 2016, p. 84), BI practitioners engage in *data mining* to reveal hidden patterns and thus support knowledge discovery and informed decision-making. Because of the nature of their data collection and analysis, BI practitioners have their own 'architectures, tools, databases, applications, practices, and methodologies' (Alnoukari & Hanano, 2017, p. 5) to perform their intelligence functions. The purpose of automated BI systems is to enable the 'intelligent exploration, integration, aggregation and a multidimensional analysis of data originating from various information resources' (Yeoh & Koronios, 2010, p. 23). In recent years, artificial intelligence and Big Data have transformed BI by enabling the exploitation of ever greater and more varied types of data while enabling the identification of patterns in a fraction of the time previously required (Curuksu, 2018, p. 19).

Competitive Intelligence (CI)

Whereas BI focuses internally, competitive intelligence (CI) is focused externally on the environment, actors, and forces external to a company. Three activities encompassed by competitive intelligence identified by Sassi, Frini, Abdessalem, and Kraiem (2015), as shown in Figure 2, are *market intelligence,* the identification of current and future customer needs and desires; *competitor intelligence,* the identification and assessment of competitor intentions, capabilities, and activities; and *technological intelligence,* the identification and assessment of new technologies and trends relevant for the client's business.

There are other significant differences between BI and CI. Not only are the actors and activities of interest to CI external to a company, so, too is the great majority of the data sought, acquired, and analyzed by CI practitioners. 'A key maxim of competitive intelligence is that 90% of all information that a company needs to make critical decisions are to understand its market and competitors is already public or can be systematically developed from public data' (Yin, 2018, p. 533).

The data and information sought by CI practitioners are frequently acquired from publicly available information sources, either online or in printed documents. It has been estimated that Google 'has only indexed 0.004% of all Internet pages' (Dominguez, 2015). This means that the vast majority of information on the Internet exists in the *Deep Web,* so-called because that information is not search engine-optimized, and thus is not identifiable and retrievable using popular search engines like Google or Bing. Consequently, *publicly* available does not necessarily equate to *readily* available, or even readily identifiable; one of the most valued skills of an experienced CI practitioner is knowing where certain types of information reside and how to locate and access that information. Another difference between BI and CI is that, whereas BI looks at current and historical data to make judgments about the present and recommendations for the future, CI is almost exclusively focused on the future. Indeed, one thing CI can provide that BI cannot is *intent.* Press releases and news reports may reveal that Company XYZ is opening a new production facility in Southeast Asia, job announcements may reveal the type of specialized engineers that the company is seeking to hire in Bangkok, and other information from social media and other sources may provide additional insight as to what is happening. Where CI really shines, however, is in the ability of CI practitioners to identify knowledgeable individuals who are not only able to provide information that answers questions beginning with *what,* but also (and more importantly) those that

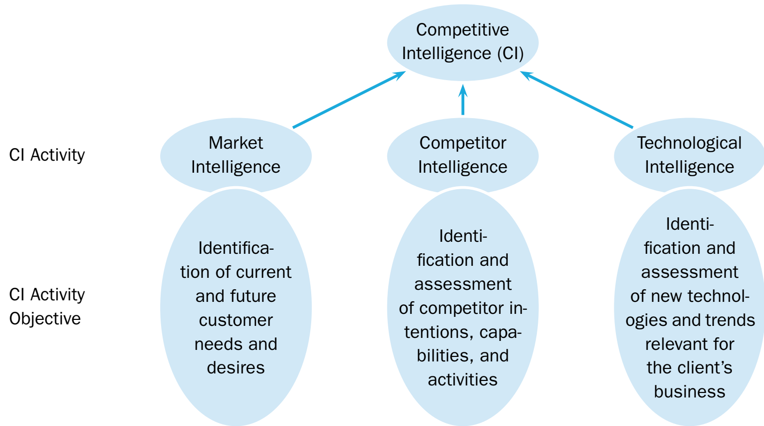


Figure 2 Three Activities Encompassed by Competitive Intelligence

begin with *why.* Quite often, such information resides with individuals, and CI practitioners engage in primary source collection to obtain information from knowledgeable sources. Although CI often involves the acquisition of information from human sources, CI 'is not espionage or spying; both are unlawful' (McGonagle, 2016, p. 55).

Additionally, distinction between BI and CI is that CI can be said to have both an *offensive* and a *defensive* side: not only can CI practitioners advise a client based on information acquired about competitors, they can also point out to a client what information competitors might be able to acquire about the client's own company (Liebowitz, 2006).

Like BI, CI has also been the beneficiary of advances in technology. CI practitioners increasingly employ specialized CI software products to monitor industries, technology trends, web-based resources, blogs, social media, and other content (Keiser, 2013). Although human cognition remains central to competitive intelligence analysis, automated systems enable more efficient acquisition, filtering, analysis, and retrieval of information in ways that were previously done manually.

Decision Intelligence (DI)

Compared to AI, BI, and CI, there is less consensus in the literature as to the meaning of the term Decision Intelligence (DI). For the purpose of the A2E Integrated Intelligence model, we define DI as taking the data and information acquired via BI and CI and reflecting on it within the context of institutional and decision-maker knowledge and experience, much (but not all) of which is tacit in nature and formalized, and contained in the organization's KM system.

Hanning (2002) describes DI as the combination of KM and BI. In their analysis of the relationship between KM and BI, Herschel and Jones (2005) note, ‘BI focuses on explicit knowledge, but KM encompasses both tacit and explicit knowledge’ (p. 45). This is a powerful distinction, one that is central to our characterization of DI: whereas BI provides explicit, current knowledge from within the organization, and CI provides explicit, current knowledge external to the organization, KM can serve as a prism through which organizational leaders can leverage institutional and personal experience (tacit knowledge) to better contextualize the BI & CI-provided explicit knowledge and make wiser decisions. Google’s Chief Decision Scientist Cassie Kozyrkov thought of DI as ‘augmenting data science with the behavioral and managerial sciences and the key here is that, in order for us to let the data drive the decision, that decision context has to be framed upfront’ (Moser, 2019, p. 1).

Farrell (2017) describes KM as ‘the active engagement of applying information with human expertise to facilitate decision-making’ (p. 675). One organization that has institutionalized KM to improve decision-making is the US Army’s Centre for Army Lessons Learned at Fort Leavenworth, which is tasked with not only capturing, analysing, and storing information about past activities and operations, but also with systematically disseminating new knowledge and insights to commanders in the field to facilitate informed decision-making.

Emotional Intelligence (EI)

In our everyday application of our knowledge and work experiences in resolving issues, both hard and soft skills are often used. Hard skills in managing projects such as scheduling, budgeting, and risk management are foundational activities for project managers. Soft skills such as negotiating, communicating, and dealing with interpersonal conflict are also important aspects of an effective project manager. Sadly, soft skills are often overlooked in the hiring process. An effective hiring manager values soft skills as much as hard skills. Hard skills are often easier to learn than soft skills due to the fact that soft skills are nurtured to us during our early childhood.

Salovey and Mayer (1990), two psychologists, coined the term ‘emotional intelligence.’ Emotional intelligence is about dealing with feelings, emotions and our relationships with ourselves and with others. Goleman and Cherniss (2001) state that emotional intelligence refers to ‘the abilities to recognize and regulate emotions in ourselves and in others.’ Consistent with Salovey and Mayer (1990), Barling, Slater, and Kelloway (2000) describe emotional intelligence as having the following five characteristics: ‘1. understanding one’s emotions; 2. knowing how to manage them; 3. emotional self-control, which includes the ability to delay gratification; 4. under-

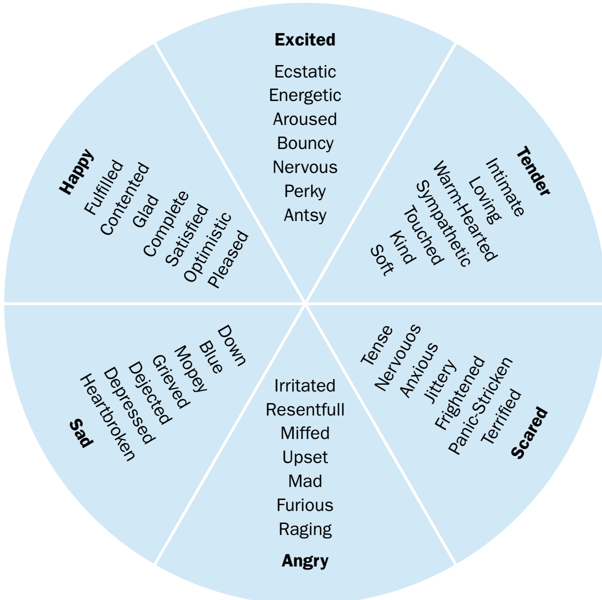


Figure 3
SASHET Framework

standing others' emotions, or empathy; and 5. Managing relationships' (p. 157).

Figure 3 displays Carlson's SASHET framework, which stands for Sad, Angry, Scared, Happy, Excited, and Tender (Carlson, 1988). The framework defines six primary feeling words to represent groups of emotions. The SASHET framework includes three 'negative' (sad, angry, and scared) and three 'positive' (happy, excited, and tender) families of emotions that can be used to distinguish between the various groups of emotions (Mersino, n.d.).

Caruso and Salovey (2004) state that emotion is information, as one of the six principles of emotional intelligence. Emotions are our own personal radar, and it provides us with a constant flow of information about ourselves, the surrounding people and our environments.

Table 1 depicts Goleman's framework of emotional competencies (Goleman, Boyatzis, & McKee, 2002). The framework is made up of four quadrants: the left two quadrants (self-awareness and self-management) focus on the self and represent personal competence, while the right two quadrants (social awareness and relationship management) touch on others and represent social competence (Mersino, n.d.).

Self-awareness is the first building block of emotional intelligence. It is important to understand how we feel and accurately assess where we are at our emotional state. We need to know 'what is going on with us' and

Table 1 Goleman's Framework of Emotional Competencies

	Self (Personal Competence)	Other (Social Competence)
Recognition	Self-Awareness • Emotional self-awareness • Accurate self-awareness • Self-confidence	Social Awareness • Empathy • Service orientation • Organizational awareness
Regulation	Self-Management • Self-control • Trustworthiness • Conscientiousness • Adaptability • Achievement drive • Initiative	Relationship Management • Developing others • Influence • Communication • Conflict management • Leadership • Change catalyst • Building bonds • Teamwork and collaboration

Notes Adapted from Goleman, Boyatzis, and McKee (2002).

accurately assess our own strengths and weaknesses. We need to have 'self-confidence' – the ability to be grounded, secure, and self-assured in whatever situation we find ourselves. Once we gained an understanding of our self-awareness, we apply self-management to manage, guide, and control our emotional state. Self-management is the ability to control our emotions (Mersino, n.d.).

Social awareness happens when we expand beyond our self-awareness to include emotions of those around us. The domain of social awareness includes empathy, organizational awareness, seeing others as they are, and emotional boundaries. Empathy is the 'ability to understand and relate to the feelings of others.' Organizational awareness is the ability to interpret emotions in the context of an organization, whereas seeing others as they are enables us to accurately assess and understand others. The domain of emotional boundaries help define where we end and where others begin. Relationship management – the last building block, ensures that we use the awareness of our own emotions and those around us to build strong relationships (Mersino, n.d.).

A2E Integrated Intelligence Model

The A2E Integrated Intelligence model as depicted in Figure 4 integrates the five different types of intelligence along the DIKW hierarchy. AI is placed at the data level as a tool to enable the collection and processing of large volumes of data. AI is conceptually defined as any ICT that supports the process of learning from data including sensory devices, software tools, machine learning algorithms, statistical models, and big data and analytics platforms. BI and CI deal with the collection and processing of data from inside and outside the boundary of an organization, respectively, using

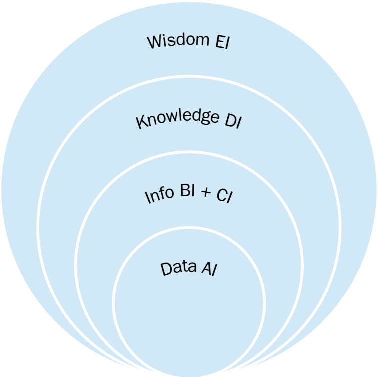


Figure 4
A2E Integrated Intelligence Model

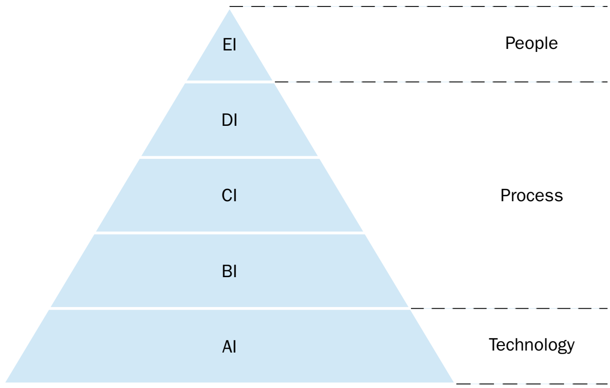
AI as the tool. BI is about using reporting tools and enterprise data warehouses to learn about internal strengths and weaknesses and to improve the internal business operations. CI is about collecting information from various external sources to help understand the competitive environment as a way to ward threats and leverage opportunities. DI is the disciplined, data-driven, evidence-based, decision-making process that leverages AI, operations research, simulation and optimization, which relies on the information collected and knowledge gained from BI and CI. EI represents the ultimate human factors that drive the decision making, including the intangible and tacit intuitions, insights, beliefs, and judgment.

From a philosophical point of view, AI follows the positivist paradigm. The positivist's worldview is technology-focused and seeks objective truth of knowledge using scientific methods possessing quantitative, deterministic, and reductionist characteristics. Positivism informs computer science and engineering, whereas BI and CI align with the paradigm of constructivism, which is people-focused and holds that knowledge is created or constructed through human collaboration in a social context. The constructivist method of inquiry is qualitative and inductive in nature. Constructivism informs social science. DI is rooted in the pragmatist worldview, which is organization-focused and emphasizes the practical application of knowledge. Pragmatism informs management science. EI is rooted in the paradigm of ethics, which is humanity-focused and places ethical judgment, values, purposes, meanings above everything else. Ethics informs religions and cultures.

The A2E model can also be described using the commonly-used People-Process-Technology framework, introduced by Leavitt (1976) and depicted in Figure 5. In this view, AI represents the technology and serves as the enabler, EI represents people and serves as the driver, while BI, CI, and DI represent the processes by which people employ technology to collect data, analyze information, discover knowledge, make decisions, and even-

Figure 5

People-Process-Technology Framework



tually effectuate organizational changes to achieve optimal performance.

The A2E model aligns with KM in that EI represents the tacit knowledge embodied in people, whereas AI represents the explicit knowledge processed by technology. Tacit knowledge is 'a knowledge that we cannot tell' (Polanyi, 1966, p. 5), while explicit knowledge 'can be codified or described using languages and other conceptual means' (Wang, 2018). Nonaka and Takeuchi (1995, p. 36) contracted tacit and explicit knowledge as 'knowledge of experience (body)' vs. 'knowledge of rationality (mind).' Skovira (2012) identified the alignment between tacit knowledge and Eastern mystical philosophy, and between explicit knowledge and Western scientific philosophy. While tacit knowledge can be frequently codified with modern technology into explicit knowledge, the cost of codifying can be greater than the benefit of it. Sharing tacit knowledge requires face-to-face communication and collaboration. The A2E model integrates technology and humanity, explicit and tacit knowledge, science and wisdom, and provides a holistic conceptual approach to decision-making and problem-solving.

In a complex and ever-changing world, the key to organizational performance and longevity is adaptability, which requires organizational leadership to look both inward (BI) and outward (CI), while integrating technology (AI) with best practices (DI) and humanity (EI). How these five different types of intelligence can enable organizational leadership to make decisions that will not only result in survival, but success, is the purpose of the A2E Integrated Intelligence model.

The Best Buy Scenario

The following sections discuss the five types of intelligence and how each played a role with respect to the Best Buy scenario described earlier in the Introduction section.

Artificial Intelligence (AI)

One advantage Best Buy has over Amazon 'is the ability to bridge on- and offline personalization' (O'Brien, 2018) through the use of a mobile phone application. 'Walk into the store and the app enters "local store" mode, sending relevant push notifications and tailoring the experience to that location's inventory. There's also an *On My Way* feature that lets sales associates know when someone is on their way to pick up an online order' (O'Brien, 2018).

Business Intelligence (BI)

For executives faced with a challenge like the one confronting Best Buy, BI would be useful for examining the company's *internal* capabilities. For example, statistical analysis of existing company data could aid in strategic exercises, to test the financial implications of a certain strategy: 'What if we lowered the price on that model television by X dollars, but sold 500 more?' Statistical analysis would also be useful for evaluating the following scenario: 'We have over 1,000 stores in the US; what if we turned some of our larger stores into mini-distribution center hubs to get desired products to all our retail stores faster?'

Competitive Intelligence (CI)

For Best Buy executives, then, CI capabilities would have been useful for gathering data and information responding such information requirements as: (1) What are the current trends in consumer electronics purchases? (2) What are our less-successful competitors doing wrong? (3) What are our more-successful competitors doing right? (4) What aspects of the online shopping experience do consumers dislike? (5) How could we better leverage our relationships with manufacturers to improve the in-store buying experience and boost in-store sales?

Decision Intelligence (DI)

It is such a combination of accumulated, tacit knowledge (derived from human expertise) and current information that was reflected in Best Buy CEO Hulbert Joly's decision to institute a price matching system, which, on the face of it, makes little economic sense: How could a brick-and-mortar operation like Best Buy possibly compete with online retailers operating with considerably less overhead? Certainly, data and information from BI and/or CI would suggest to Joly that price matching an online retailer having much lower overhead than Best Buy would be financially unsound. Rather than be guided by these data inputs, Joly instead drew upon his tacit knowledge and experience to opt for an unconventional, if not counter-intuitive, approach based on the logic that, by removing the financial incentive for a prospective buyer to go home and order an item from a competitor online, this would boost the likelihood that a visitor to a Best Buy store would simply purchase that product on the spot. Joly's unorthodox strategy 'costs Best Buy real money, but it also gives customers a reason to stay in the store, and avoids handing business to competitors' (Roose, 2017). Explicit knowledge from BI and CI would not have led Joly to reach such a decision; rather, it was Decision Intelligence, Joly's reflection on explicit data (such as from BI and CI) – but within the context of his business knowledge and experience – that did so.

Emotional Intelligence (EI)

One of the things Best Buy's new CEO, Hubert Joly, did after taking over the company was to look inward, at Best Buy's organizational culture and its people. In this way, Joly effectively employed emotional intelligence to become the kind of tribal leader described in Logan, King, and Fischer-Wright's (2008) book, *Tribal Leadership.* 'Tribal Leaders focus their efforts on building the tribe, or, more precisely, upgrading the tribal culture. If they are successful, the tribe recognizes them as the leaders, giving them top effort, cult-like loyalty, and a track record of success' (Logan, King, & Fischer-Wright, 2008, p. 3). As an effective tribal leader, Joly recognized that for Best Buy to compete with Amazon, 'it needed to get better at things that robots can't do well – namely, customer service' (Roose, 2017). Some of the steps Joly undertook to improve organizational culture and motivate employees included visiting Best Buy stores to speak with employees, working at one of his stores for a week, investing in employee training, and bringing back an employee discount program that had previously been eliminated (Bariso, 2019). 'You need to capture the hearts and minds of the employees,' Joly said (Roose, 2017). Joly's approach of putting people before technology not only extended to Best Buy employees, but also to the company's philosophy about, and approach to, its customers. According to Joly, Best Buy's mission is to 'enrich lives through technology,' and to accomplish this by 'addressing key human needs in areas such as entertainment, productivity, communication, food preparation, security, and health and wellness' (Garcia, 2018).

Summary

As Amazon began to inexorably eat away at the market share long comfortably dominated by such traditional brick-and-mortar firms as Sears, JCPenney, and Best Buy, executives at these (and many other) retail firms struggled to find ways to not only remain competitive, but simply survive Amazon's onslaught. All three firms had the financial resources necessary to invest in, and leverage, artificial intelligence and big data. All three firms had in-house business intelligence analysts to 'run the numbers' and make recommendations. All three had competitive intelligence practitioners experienced in examining the external environment and competitive landscape and reporting on market, competitor, and technology developments and trends. What differentiated the experience of Best Buy from that of Sears and JCPenney, however, was not the technology-enabled acquisition of new, explicit knowledge, but rather the cognitive application of tacit knowledge, gained through human experience, to serve as a filter for explicit knowledge and facilitate the creative formulation of a new, and effective business strategy. In stark contrast to retail behemoths Sears and JCPenney, Best Buy not only staved off disaster, but effectively responded to Amazon's online retailing challenge 'through a brilliant combination of corporate strategy and *emotional intelligence*' (Bariso, 2019). Instead of looking to technology for answers, Amazon's CEO instead turned to people; the people within his own organization, and the people Best Buy sought to retain, and acquire, as loyal customers.

Best Buy's story serves as a representative case study to illustrate how decision-makers can apply the A2E model to improve organizational performance by balancing technology with humanity. Because DI and EI played such a prominent role in its new strategy, Best Buy was able to make more effective use of technology and data to support it: Looking inwardly, Best Buy leveraged BI capabilities, on-hand company data, and statistical analysis to figure out how to turn some of their stores into mini-distribution hubs for online customers, who then had the choice of picking the item up locally or having it shipped to their door (Bariso, 2019). Looking outwardly, Best Buy leveraged CI to approach electronics manufacturers like Apple and Samsung and negotiate agreements under which those companies would 'rent footage within Best Buy to feature all their products together in a branded space' (Bariso, 2019), which created a new source of revenue for Best Buy. Decision intelligence came into play when Joly implemented a counterintuitive price matching policy (Roose, 2017). Emotional intelligence is what caused Joly to recognize the importance of improving organizational culture and enabled him to become an effective tribal leader.

Conclusion

Decision Support Systems have existed for decades, and today firms are turning to such promising technologies as big data, machine learning, and artificial intelligence to help guide strategy development and improve organizational performance. While technology is a powerful enabler, it is not a panacea; the reality is that technology alone is insufficient for informed, wise decision-making and problem-solving. Human intelligence must also be effectively brought to bear. In line with this assertion, this paper introduces the A2E (Artificial Intelligence to Emotional Intelligence) Integrated Intelligence Model, which blends technology and humanity to support strategic decision-making. The A2E model builds upon the Data-Information-Knowledge-Wisdom (DIKW) hierarchy and Knowledge Management (KM) concepts including tacit and explicit knowledge as its theoretical foundation to integrate five different types of intelligence into a unified and coherent framework: Artificial Intelligence (AI), Business Intelligence (BI), Competitive Intelligence (CI), Decision Intelligence (DI), and Emotional Intelligence (EI). While these five concepts represent five different approaches and perspectives, and are studied and practised within five different disciplines, they are inherently related and complementary. Integrating them into a cohesive framework provides a simple, yet powerful, mental model to help organizational strategists and business executives conceptualize an effective approach to problem-solving.

In addition to describing each of the five intelligence types incorporated in the A2E model, this paper uses the US-based consumer electronics retail giant Best Buy as a case study to illustrate the relevance and efficacy of this model in a real-world business scenario. The survival and prosperity of Best Buy in a challenging retail environment demonstrate the benefits of applying all five types of intelligence to overcome weaknesses and threats, leverage strengths and opportunities, and ultimately achieve optimal organizational performance.

Implications

As the Best Buy case study richly illustrates, the A2E Model offers a simple, yet powerful, framework for helping business executives not only conceptualize strategies for managing such common business challenges as fierce competition and complex operating environments, but also for successfully addressing the kind of fast-emerging opportunities and threats brought about by rapid innovations in ICT.

Both the A2E model and the Best Buy case study illustrate that, while technological developments are important, both in terms of threats and opportunities, that importance must be kept in proper perspective. As Gerd Leonhard (2016) eloquently observed, 'Technology is not what we seek, but how we seek.' In short, technology should be viewed as the means to an end, and not as the end in and of itself. AI is a powerful technological tool for addressing the *how,* which in turn enables BI and CI to address the *what, where,* and *when,* whereas DI and EI are best suited to answer the strategic decision-maker's ultimate questions of *why* and *whether.*

Less than a decade ago, Sears, RadioShack, JCPenney, and Best Buy were all successful, peer competitor retailers that seemingly overnight found their once-dominant, long-standing business models seriously challenged by the technology-facilitated, disruptive threat posed by online retailer Amazon. Only one of those firms (Best Buy) successfully responded to the emerging, existential threat; the other three failed to do so, with catastrophic consequences for each of those firms. A structural decomposition of Best Buy's successful strategy reveals that the company effectively leveraged all five intelligence types represented in the A2E Model: Artificial, Business, Competitive, Decision, and Emotional.

Central to the A2E model, and richly illustrated by the Best Buy case, is the need for business executives to clearly grasp not only the benefits of technological innovations, but also their attendant risks and limitations. However, the A2E model is not only about technology: central to the model is the critical importance of humanity. For example, when embracing AI as a means to increase operational efficiency through automation, executives must at the same time remain mindful of unintended, second-order consequences and creatively leverage human agency to mitigate those risks. Keeping a human-in-the-loop, and applying EI to augment AI are good strategies and keep businesses in the state of balance.

A final implication of the A2E model, also prominently featured in the Best Buy case study, is the criticality of vision and values for formulating a successful strategy. Vision and values flow from the wisdom of the company's leadership. Wisdom is at the pinnacle of the DIKW pyramid, while EI is the highest-order intelligence in the A2E Model. Consistent with the A2E model, Best Buy CEO Joly not only devised a business strategy that effectively leveraged technology, but at the same time recognized, embraced, and committed adequate resources to training, motivating, and equipping employees with the knowledge necessary for successful implementation of the strategy. Vision and values are central to corporate culture, and the corporate culture of Best Buy in 2019 was radically different from the culture that existed in 2012.

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Digital Inequalities

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The proliferation of digital technologies in most countries brings significant benefits from their use. These so-called digital dividends have a positive impact on economic growth, widening the scope for socio-economic development. However, their unequal distribution across countries makes digital technologies not equally beneficial to all countries and entities, and is gradually deepening the digital divide resulting in a gap in terms of between-countries income inequalities. These can be afterwards translated into other socio-economic characteristics of the countries. In the paper, we evaluate the digitization level of EU countries within the panel of 62 world's countries. Using the data envelopment analysis (DEA) method, we examine the extent to which unequal distribution of digital readiness across countries translates into the level of their economic performance. At the same time, we identify potential digital enhancements to bring the country closer to efficiency.

Keywords: digital inequalities, socio-economic development, data envelopment analysis, economic growth

Introduction

Economic development in both global and regional dimensions is increasingly influenced by the rapid development of information and communication technologies, by the use of big data, metadata, digitization, and the development of artificial intelligence. The mentioned processes bring unprecedented dynamics of changes in economic processes, institutional structures, ways of creating wealth (and its distribution), social and cultural relations. The creation of new intelligent digital networks penetrates all spheres of society – it is changing forms of well-being, the nature of work, the conditions for applying to the labour market, the way people interact, the nature of economic-political decisions.

A country's ability to create conditions for economic growth and increase its competitiveness is increasingly conditioned by the level of its digital maturity. At the same time, maintaining a high level of digital progress depends on the country's economic level; economically advanced countries generally reach higher digital levels. According to the European Commission (2017), digitization allows higher productivity through the whole economy, which conducts to lower prices and higher real income, while increased real income tends to higher standards of living. Some researchers though point out that digitalization itself does not ensure increasing returns in productivity and that has negative impacts on social domains not limited to labour demand.

The development of digital processes is particularly important because there is a close link between the level of digitization and the country's economic performance. Digitally developed countries are usually leaders in the creation, management and use of digital technologies, and use these technologies very effectively. They are able to continually create new digital impulses and create new demand for digital technologies. Maintaining a high level of digital progress promotes the growth of their economic performance, which subsequently supports the development of digital innovations and technologies, creating a positive growth circle. Low levels of digitization makes a country less attractive to investors.

The reverse side of unprecedented opportunities and benefits of digital infrastructure, applications and meta-data include many challenges and dilemmas that digital technology brings. New asymmetries arise, the so-called 'digital divide,' in terms of unequal conditions in access to information and communication technologies, resulting in very different impacts on performance and competitiveness of companies, regions, countries. It has the potential to create inequalities both on occasions and in output (income, wealth).

In this article, we will focus on the macroeconomic aspect of the impact of digitalization on inequality in the output, which will be evaluated with GDP per capita. We examine the interconnection of digital levels and economic performance evaluating the extent to which the effective absorption of individual elements of the digital maturity to the economic development of the country. Considering economies as entities that employ resources in order to deliver desirable outcomes, the question of efficiency of such transformation arises. The nonparametric method used allows to determine best practice countries forming efficiency frontier that acts as benchmarks for evaluation. For inefficient subjects, sources of potential improvement could be identified.

Literature Review

Digitization penetrates all spheres of society, creating strong impulses for economic development, brought to the fore by unprecedented dynamic changes in economic processes, institutional structures, ways of wealth creation (and distribution), social and cultural relations. Significant digital innovation creates room for improving efficiency in the use of growth factors, enhancing institutions and services, expanding space to improve quality of life for inclusive and environmentally sustainable growth. Digitalization is the first lever of growth for companies, it improves productivity because digitizing and automating a number of processes within companies enable them to focus on high value-added tasks and the rise of digital tools improves their competitiveness and enables them to better know and understand their customers in a favour of well-being (Garnier, 2018). Micro-level performance of the firms translates into the nation-wide macro level. Draca, Sadun, and van Reenen (2006) provide a survey of the empirical evidence that digitally mature countries tend to have rather high level of competitiveness and performance.

Countries that have firms acting as developers of platforms and managers of digital technologies are those most likely to reap the benefits that arise from the digital economy – i.e. better prospects in terms of long-term growth, job and wealth creation, and lasting positive effects on productivity and competitiveness. Their populations and firms are those that tend to benefit the most from the indirect effects of being in a richer, open, and innovative environment (Arbache, 2018). Understanding the process of digital transformation involves accepting that this transformation affects all industries; that the digital gap between developed and developing countries has been inverted as time has gone by, while users in the latter countries are becoming increasingly relevant and influential players. Although the majority of organizations are already adjusting and reorganizing to adapt to the demands of this new digital economy, not all of them are at the same stage of digital development (Cerezo, Magro, and Salvatella, 2014). Control over digital space facilitates benefits in the global competition, as well as a large part of the global market domination. World Economic Forum (2012) states that 'the economic impact of digitization accelerates as countries transition to more advanced stages.' The ongoing digital transformation promises to spur innovation, generate efficiencies across a wide range of activities, and improve well-being as information and knowledge become more widely available and democratized (OECD, 2017).

The most valuable factor in the digital economy is intellectual capital, innovative ideas and intangible assets, while the importance of tangible assets recedes into the background. As a result, demands for education and skills are increasing. In the context of the need to restore productivity growth, the focus has recently been on increasing the share of intangible investment in total investment (Thum-Thysen, Voigt, Bilbao-Osorio, Maier, and Ognyanova, 2017) This has a strong potential to influence factor efficiency and growth of total factor productivity (TFP). Intangible investments improve productivity and capital, increase the growth impact of innovation, counteract declining returns and account for up to one fifth of the labour productivity growth in the EU (Corrado, Haskel, Jona-Lasinio, and Iommi 2016). The growing share of intangible components in the final value of goods, coupled with the increasing ease of access to digital technologies, platforms, and advanced capital goods, are radically transforming our understanding of the production and distribution of wealth. It is no exaggeration to predict that firms will increasingly rely on artificial intelligence for basic routines and for more complex tasks (Arbache, 2018). In the future, the factors that enable economies to invest in information and monetize new knowledge and discoveries will be key drivers of growth. So, for example, IP policy is likely to be of increasing importance along with broadband/communications equipment. Digital technologies can have considerable impacts on productivity growth (Czernich, Falck, Kretschmer, and Woessman, 2011), but only when investments in ICT (Information and Communication Technologies) are combined with investments in complementary assets, such as skills, organizational changes and process innovations, i.e. knowledge-based capital (OECD, 2004).

Digitization also facilitates the creation of new and better products and services with fewer resources, reduces physically demanding efforts and exposure to dangerous activities in the workplace. Much of this is yet to come. For those embracing this revolution with technological know-how, the digital economy offers plenty of opportunities: for IT-savvy workers, for creative people, for SMEs, for traditional industries, for disadvantaged regions, etc. (European commission, 2017). Discounting sensors and other digital devices and their gradual miniaturization allows their involvement in mass production processes, transport and energy networks, households, health care, financial institutions, etc. (European Commission, 2017). According to the *Harvard Business Review* (2017), digital technology, automation, artificial intelligence and metadata could influence about 50% of the world economy, while the current technology can automate more than a billion jobs (14.6 billion US dollars in the form of wages).

On the other hand, digitization poses serious risks to many areas. It brings a lot of uncertainty, 'disrupts society ever more profoundly and, as a result, concern is growing about how it is affecting issues such as jobs, wages, inequality, health, resource efficiency and security' (World Economic Forum, 2018). Inflexible management of digital processes would push the country into a digital backwater narrowing its potential for socio-economic development. The speed of development of digital processes and the ability to manage them creates room for digital inequalities between countries. Digitalization, like previous technological advances, will have repercussions on labour markets. Some jobs will be replaced, some will be created, and many will be transformed. A more efficient use of human energy brings a high risk of replacement of routine work activities, generally performed by low-skilled labour force, increasing thus social inequality. For the moment, it is impossible to estimate the job replacement and job creation effects with any degree of certainty. For some developed countries, a preliminary assessment was carried out by Eichhorst, Hinte, Rinne, and Tobsch (2016). Though for every job destroyed by the Internet, 2.6 jobs is created (McKinsey Global Institute, 2011), new jobs may not go to the same people as the old ones, and may not go to the same geographic areas (European Commission, 2017). In this way, digitization can affect the positive or negative range of inequalities.

Empirical work supporting the decision-making process on the macroeconomic level has so far employed parametric regression analysis focusing predominantly on the impact of digitalization on performance, e.g. Katz and Koutroumpis (2013), Kretschmer (2012), Gruber, Hatonen, and Koutroumpis (2014). Since digital readiness plays a critical role in determining countries' future growth paths, a suitable supportive benchmarking analytical method is needed to identify shortages. With this regard, a non-parametric benchmarking tool is more appropriate providing a routine for multidimensional assessment. Policy-makers could thus concentrate efforts and utilize public funds in the most efficient manner. The next section explains the measurement of digitalization maturity and progresses to efficiency assessment.

Data and Methodology

A common feature of the assessment of digitization is the assessment of the quality of support and the pace of development of digital technologies, potential of the digital economy and digital impulses. The process of shaping the digital industry is also examined along with its attractiveness to the market and access to the digital market. In assessing the quality of digital transformation, most of the focus is placed on examining the educational level of the country and its scientific and research potential. Great importance is also given to assessing the quality of the institutional framework, as the potential of the digital economy and digital impulses is highly diversified in individual countries due to divergent regulations, economic development and economic policies.

Success of managing the digital transformation process in all its aspects reflects the level of digital competitiveness that has recently been explored by the International Management Development Institute (IMD). IMD perceives digital competitiveness as an economy's ability to adapt to digital technologies that accelerate change across the public and private sectors within the whole society. On the basis of hard and soft data, it evaluates 50 criteria that include organizational, institutional and structural aspects conditioning the digital development of the country and that make it possi-

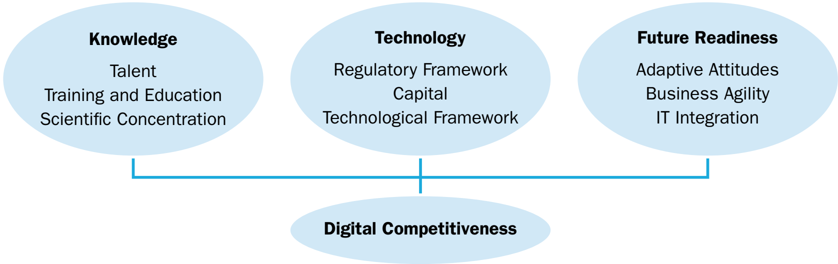

Figure 1 Model of Digital Competitiveness (adapted from IMD, 2017)

ble to assess its strengths and weaknesses. The Compilation Scheme of The World Digital Competitiveness Index (Figure 1) is based on three basic factors into which individual criteria are incorporated.

From the IMD point of view, the development and absorption of digital technologies is essential for the development of the intangible infrastructure of a country, which is assessed through a sub-factor of knowledge. The focus is primarily on the ability to discover, understand and use new technologies. The assessment of the availability of researchers and scientists (the level of outflow of high-tech researchers and the ability to attract highly skilled workers from abroad) is assessed, the level of research spending on development, the quality of scientific-research capacity (given the concentration of knowledge creation needed for the digital transformation of the economy).

The quality assessment of the technology environment is geared to the country's ability to develop digital innovation and technology. Within the technological environment, the extent to which supportive regulatory framework creates the conditions for the effective functioning of business dynamism and innovation is examined. The availability of capital and the level of investment in technological development is also assessed. The degree of investment risk in the country under assessment, and the extent and quality of physical technology infrastructure is taken into account. Finally, the level of high-tech production is considered in the country. The last factor in digital competitiveness reflects the economy's readiness for future development, the success of adaptation to innovative ideas and technologies, and it assesses the level of agility in the country, as well as the level of integration of digital technologies into the economy. The country's position in digital competitiveness reflects the success of its digital transformation. The maximum value of the World Digital Competitiveness Index (100) is assigned to the most digitally available country. The IMD evaluates 63 countries as part of the global digital competitiveness assessment. Quality of individual sub-factors and their components determine the efficiency of digital potential into economic performance transformation. The question that arises is to what extent the digital quality measured by the level of digital competitiveness translates into the economic achievement of European countries or whether there is a potential for improvement in this ‘transformation process.’

With the multidimensional measure of digitalization at hand, we proceed to examine how efficiently this resource translates into the economic outcome. Quantitative assessment could be facilitated by conceiving a transformation process with economic performance as output reinforced by digital capacity as multidimensional input. Other determinants are contained in the black box of the technology of transformation. The goal is to assess the efficiency of that transformation. In general, for evaluating technical efficiency of the processes involving quantities for which no market prices exist, data envelopment analysis (DEA) models are often used. In DEA, a black box technology (transformation) efficiency is defined as the ratio of the outgoing and entering quantities permitting possible multidimensionality of both. Typically, efficiency scores range between 0 and 1, the latter score value being ascribed to the relatively efficient subjects. These best practice entities make up the *efficiency frontier.* Against that boundary, all the other subjects are then benchmarked. The efficiency score reflects production of the output, given the amount of inputs. In our proposed model, countries (entities under evaluation) with higher scores would achieve higher levels of wealth, given the level of their digital competitiveness.

The assessment itself involves solving an optimization problem employing output-oriented SMB model (Tone, 2001):

$$\rho = 1 + \frac{1}{m}\sum_{r-1}^{s} s_r^{-1}/x_{i0}, \tag{1}$$

$$x_0 = X\lambda + s^-, \tag{2}$$

$$y_0 = Y\lambda + s^+, \tag{3}$$

$$\lambda, s^-, s^+ \geq 0,$$

where X and Y denote input and output data matrices, $x0$ and $y0$ are inputs and outputs of the country under evaluation. Objective function ρ represents the efficiency score while λ act as intensive variables generating the efficiency frontier. Slacks s^+ and s^- represent deviations from the best practice performance. In this setting, efficient units’ (countries) score is unit, efficiency score of the rest is given by $1/\rho$. Thus all the subjects under evaluation can be ordered by their performance. Moreover, decomposition of inefficiency is possible to identify potential for improvement in specific domains of assessment. The technology is assumed to exhibit constant return to scale.

In our model, GDP per capita is acting as an output proxy for economic performance, data is placed in matrix *Y*. (IMF, 2018). The input data (matrix *X*) entering the model – three components of the digital quality – come from the IMD World Digital Competitiveness Ranking (2018). Taking a global perspective, we assess the European countries within the set of the world's countries, allowing for benchmarks to be found outside of Europe itself.

Results and Discussion

The efficiency of transforming the digital maturity of a country into its economic performance depends on the quality of the individual factors that enter the design of the digital competitiveness index. As shown in Figure 2 (figures in brackets), the United States is the digitally most competitive, which has replaced Singapore in this position. From European countries, the Scandinavian countries, Switzerland, the Netherlands and the United Kingdom rank best in terms of digital competitiveness. Significant improvements in the relative position of digital competitiveness have been achieved by Bulgaria, Austria and Romania over the last five years. The negative development of digital competitiveness is the deterioration of several countries, especially Greece (a 35-digit deterioration in the digital competitiveness index), as well as Hungary and Slovakia, whose positions have dropped by 10 seats. Slovakia is the last third within the assessed countries, currently 50th. Of the EU countries, only Greece and Cyprus report lower digital competitiveness. According to the European Commission, the potential of the EU digital economy is currently hampered by the incoherence of the European political framework, causing many European countries to lag behind the most digitally dispersed economies in the development of digital networks that underlie the digital economy and business. If we look at the percentage of digital transformation potential in the economic performance of the countries under review, in Figure 2, we see that, in addition to the US and Singapore, only four European countries managed to effectively implement the transformation process – Denmark, Luxembourg, Norway, Switzerland. Six countries form the benchmark boundary (reaching the value of one). However, Denmark, Switzerland and Luxembourg only act as peers for themselves, which is considered a sign of outlying data in DEA literature. Other countries' distance from the efficiency frontier is much more differentiated.

Sweden and Finland are relatively close to the border of the effectiveness within the EU countries. These least-penalized countries achieve roughly the same level of inefficiency or penalties, as the level of efficiency of transforming digital competitiveness parameters into economic performance achieved by Cyprus, Hungary, Greece, Romania and Slovakia. Regarding the structure of potential improvement, the lowest level of improve-

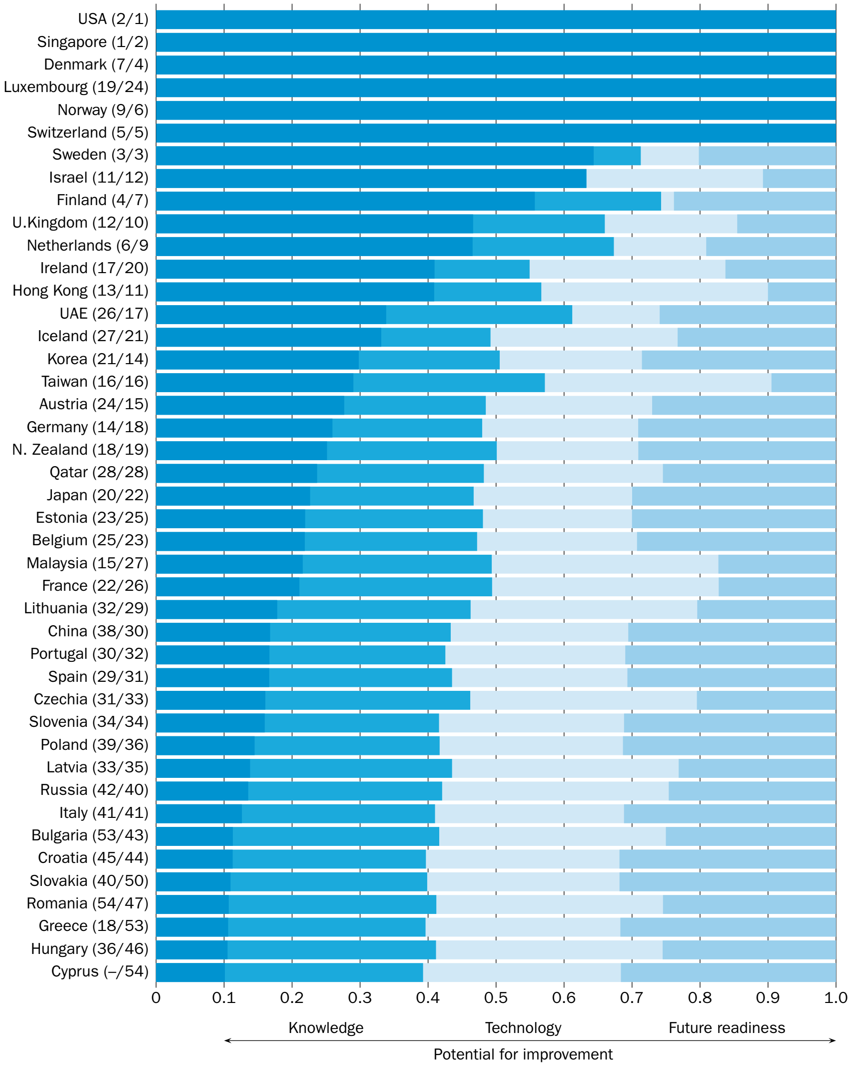

Figure 2 Efficiency of the Digital Quality-to-Economic Performance Transformation (numbers in brackets represent change in rank between 2017 and 2018; authors' calculation based on IMD, 2018)

ment is in education. The most digitally competitive countries are increasing the demands on intellectual capital, quality of education and digital skills. Within penalized countries, only Israel has managed to fully transform education into its economic performance. Education has contributed very little to the overall level of penalization in Sweden, but also in Ireland, Finland, Iceland and the United Kingdom. Many EU economies achieved a very high degree of penalties in education. Hungary, Romania, Bulgaria, Latvia, as well as Cyprus, Greece and Slovakia, have the lowest ability to discover and exploit new technologies and to support the development of research capacities for digital transformation.

Technology, i.e. the ability of countries to develop digital innovation and technology and to promote innovative dynamism is one of the sub-factors of digital competitiveness, the percentage of transformation in economic performance is the lowest within the countries surveyed. At least, it penalizes those Nordic countries that are not on the border of efficiency, as well as the Netherlands and the United Kingdom. Among EU countries, Romania, Bulgaria, Hungary, Latvia and Lithuania are the least effective at transforming the technology sub-factor into their economic performance. In the area of economic readiness for future development, Taiwan, Hong Kong and Israel are lagging behind effective countries at least. Within the EU, the United Kingdom, Ireland and France achieve the lowest distance from the most effective countries. The least disposed countries in the region are Croatia, Slovakia, Greece, Cyprus and Poland.

Conclusions

Despite the fact that the EU sees huge growth potential in the successful digital transformation of its countries and creates platforms for its support and development, the position of most of its countries in digital competitiveness has deteriorated over the past 5 years. The lagging of most EU countries behind the most digitally competitive countries suggests their lack of preparedness for the challenges of the digital age in all sub-factors. These facts make the extent of inefficiency in transforming digital maturity into economic performance conditional. The potential for improving countries that are below efficiency is mainly in the digital age of people and businesses. Inefficient countries must create the conditions for increasing the level of digital education, improving the quality of mathematical and technological knowledge, and creating the conditions for attracting highly qualified students and workers to the country.

A prerequisite for the growth potential of the education sub-factor is to increase spending on research, development and investment in education, in particular digital education. In the technological environment, inefficient countries need to address bottlenecks in technology development and application, science and research legislation, technology development funding, investment risks, the development of the telecommunications sector, and the scope of broadband wireless connectivity. From the perspective of improving the effective transformation of digital quality into economic performance, inefficient countries need to focus mainly on digital challenges in the future, adapt rapidly to the global digital environment and increase protection against cyber threats.

The unsatisfactory position of several Member States in digital competitiveness is, on the one hand, slow or slowing. No progress (or decline) in all of its areas, on the other hand, tells that more competitive digital countries are moving much faster and more vigorously in the development of the digital society. Among EU countries, Cyprus, Hungary, Greece, in particular, are achieving a low level of digital maturity transformation into economic performance, a possible underpinning of economic development in the future. These are countries whose position in digital competitiveness has deteriorated significantly over the past five years. Despite the fact that the level of digital competitiveness is low in Romania and Bulgaria, it is positive that both countries have seen a significant improvement in their position over the period under review.

Overall, however, we can see that many EU countries are limited in their economic performance by the level of digital maturity. There is, therefore, a real threat that the current digital inequality between digitally competitive and digitally less disposed countries will eventually deepen the inequality between them.

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A Research on Schools as Learning Organizations: A Theoretical Approach

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Due to the growing pressures on the educational area to provide young people with the knowledge and skills needed to live and work in a constantly changing society and the technologies and trades that today do not exist, the model of learning organization has been extended to schools, as an attempt to re-conceptualize them from organizations that are traditionally linked to the learning and knowledge process to organizations that are capable of responding with efficiency to uncertain and dynamic environments. The purpose of this paper is to identify the state of affairs in the Romanian educational system (pre-university level) in order to provide a starting point for the implementation of the 'school as a learning organization' concept and model. The approach is theoretical, using desk research of regulations and data regarding the public expenditure in education, per capita funding, number of pupils enrolled, PISA results and correlations between the action-oriented dimensions (including their key characteristics/elements) of the model proposed by Kools & Stoll (2017) and the performance indicators (including descriptors) that are used at the Romanian national level. Results show that, between 2009 and 2018, school organizations were under increasing pressure and the implementation of this concept and model at system level could be an opportunity to focus on students from the organizational side, having the determined correlations as a foundation.

Keywords: learning organizations, schools, educational system, performance, indicators

Introduction

The challenges of the postmodern society (the emergence and development of new information technologies, the growth of inter-relational processes, the free movement of capital and the domination of multinational corporations) have led to new organizational models, as theoretical attempts of the academic and business environment, to provide solutions to the need for companies to adapt and survive: (1) the 'learning organization' – where learning (both individual and collective) and good harmonization between the individual and the organization produce benefits to both parties and underpins the achievement of performances and competitive advantage; (2) the 'network organization' – where vertical control and communication relationships are replaced by lateral collaboration and consultation relationships, which leads to greater flexibility and adaptability when issues and action requirements that cannot be broken down and distributed among specialists within a hierarchy arise; (3) the 'intelligent organization' – where competitive advantage is not obtained from high-quality, ephemeral products, but through a needs analysis and the implementation of strategies around core elements – knowledge and service-based activities.

Among these models, the 'learning organization' is the one that gets to be the most challenging due to the fact that the results of its implementation can only be identified in the long run and it is essential to encourage permanent development (continuous learning at all levels – individual, group, organizational).

Due to the growing pressures on the educational area (to provide young people with the knowledge and skills needed to live and work in a constantly changing society and the technologies and trades that today do not exist), the model of learning organization has been extended to schools (SLO – School as Learning Organization), attempting to re-conceptualize them from organizations that are traditionally linked to the learning and knowledge processes to organizations that are capable of responding with efficiency to uncertain and dynamic environments, adapting to the socio-economic and cultural conditions of the community they belong to (including student learning outcomes, both academically and ethically, self-esteem and self-directed learning abilities).

The first approach in this direction could be identified in the late 90s, when the 'Thinking Schools, Learning Nation' agenda was launched by the Singaporean Prime Minister Goh Chok Tong at the opening of the 7th International Conference on Thinking. This agenda restructured the relationship between schools and the Ministry of Education, redefined both teaching (as a learning profession) and schools (as model learning organizations) and was the cornerstone for a school improvement process at national level, in order to help schools operate as self-improving professional learning organizations. Later on, having as background five core 'learning disciplines' (personal mastery, mental models, creation of a common vision, team learning and systemic thinking), Senge, Cambron-McCabe, Lucas, Smith, Dutton, and Kleiner proposed (first in 2000, and then updated and revised in 2012) a series of landmarks on individualized teaching, curriculum adaptations to the local context and waiver learning by memorization, stressing that schools should be seen as living systems whose survival is crucially dependent on how teachers, students, parents and local governments will manage to adapt to the socio-economic transformation. The most recent international approach in this direction was made in 2017 by Kools & Stoll (2017), proposing to re-conceptualize schools based on the model promoted by Watkins and Marsick (1996), having as background seven 'specific dimensions' (continuous learning, inquiry and dialogue, team learning, embedded system, empowerment, system connection and strategic leadership); the schools are seen operating at numerous levels (individual, teams, wide communities of practices), embedded in supportive communities (Ministry of Education, Local Government, local community, parents, NGOs, higher education institutions, companies, networks of schools), with its essentials being time (for inquiry, innovation and exploration) and mutual trust. Between 2009 and 2018, the following phenomena occurred at the national educational level: (1) a general decrease in the school population (by 17% till 2016, compared to 2006), (2) the transfer of the last year's kindergarten to primary education (along with reshaping both their curriculum), (3) the gradual transformation of arts and crafts schools into technological high schools, followed, from 2014, by a strong return to professional schools, (4) a massive reorganization of the school network (many public schools lost their decision-making and administrative independence, being transformed into structures of other schools and destroying the organizational culture of both the receiving and the received school), and (5) a constant decrease of public expenditure in education (from 5.76% of total expenditures in 2009 to 3,76% of total expenditures in 2017). As a result, great pressure was felt at the Romanian educational system, with considerable repercussions on the efficiency of the school organizations.

In this respect, a research entitled 'A Study of the Evolution of Educational Efficiency: Romanian case' carried out in 2017 on a representative sample of 2,956 schools (out of a total of 6,413 schools with legal personality forming the national school network of 2017–2018) highlighted, among other things, that for the 2014–2017 period, 64.7% of schools registered a negative evolution of the efficiency index, 15.6% had a steady evolution and only 19.7% had a positive evolution (Paraschiva, Farkas, Jitarel & Draghici, 2017, pp. 6–7).

Therefore, finding solutions to help increase the efficiency of school organizations is more than needed at the national level and thus the opportunity given by the model and the concept of learning organization should be taken into account. In this context, in order to provide a starting point for the implementation of the SLO concept and model at the Romanian educational system level, two research questions are set:

1. What is the state of affairs at the Romanian educational system (the

pre-university level) during and after the international economic crisis of 2008–2015?

2. Are the elements/key characteristics of the SLO model proposed by Kools & Stoll (2017) already pursued in the Romanian educational system?

This paper provides a desk research analysis in two steps:

- on regulations and data regarding the public expenditure in education and per capita funding for the 2009–2018 period, the enrollment evolution from 2006 to 2016 and a perspective till 2030 (pre-university level) and the results on PISA evaluations – step 1;
- on correlations that could be established between the action-oriented dimensions (including their key characteristics/elements) of the SLO model proposed by Kools & Stoll (2017) and the performance indicators (including descriptors) that are used at the Romanian national level in order to establish the quality of the educational services provided by pre-university school organizations (along with other legal regulations in force at the national level) – step 2.

After regulations and data analysis and correlations are identified, conclusions and further developments are made.

Literature Review

The learning organization, as a concept and model, gained wide recognition when Peter M. Senge published in 1990 the work *The Fifth Discipline: The Art and Practice of the Learning Organization,* with five core 'learning disciplines' – personal mastery, mental models, creation of a common vision, team learning and systemic thinking. He proposes that people leave aside their old ways of thinking (mental models), to learn to be open to others (personal mastery), to really understand how their company/organization is working (not in terms of cause and effect, but in terms of connections between the various component parts – systemic thinking), to develop a plan with which everyone agrees (common vision) and then acts together to achieve this vision (team learning).

The concept has had numerous descriptions and extensions (from being defined in relation to business organizations, to be linked to non-profit organizations – hospitals, public administration, schools/universities), a learning organization (1) 'facilitates learning of all its members and continuously transforms itself' (Pedler, Boydell, & Burgoyne, 1989); (2) is 'continually expanding its capacity to create its future' (Senge, 1990, p. 14); and 'where people continually expand their capacity to create results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together' (Senge, 1990, p. 2); (3) people are 'skilled at creating, acquiring, and transferring knowledge, and at modifying its behavior to reflect new knowledge and insights' (Garvin, 1993); (4) and 'are aligned around a common vision. They sense and interpret their changing environment. They generate new knowledge which they use, in turn, to create innovative products and services to meet customer needs' (Yang, Watkins, & Marsick, 2004); (5) and, finally, will enable educational setting such as universities to strategically adapt and survive to any possible futures (Prelipcean & Bejinaru, 2016).

While it is widely accepted that practice in labor market organizations (during initial training) and teamwork (during professional performance) are contexts in which learning takes place (experiential, guided or collegiate), the school remains, however, the organization that is traditionally linked to the learning and knowledge process. Because education is no longer a luxury but a necessity, and each individual must be able to cope with an uncertain and continually changing future, schools have been subjected to enormous pressure to provide (develop) an environment capable of leading and sustaining each individual on the path of becoming. Under these pressures, the concept of SLO is also introduced, having various descriptions and perspectives over time. Such a school (1) 'devotes considerable attention to shaping the human resource management policies and procedures within the school organization to facilitate peer learning and collaboration among colleagues' (Du Four, 1997); (2) promotes 'an active and proactive adaptability in dynamic environments with different social expectations, including students with different backgrounds, geographic location (rural, suburban, urban) and socio-economic and cultural conditions of the community, government structures and administrative procedures in education at the local level' (Paletta, 2011); (3) 'can be made sustainably vital and creative, not by fiat or command or by regulation or forced rankings, but by adopting a learning orientation' (Senge et al., 2012, p. 5); (4) 'develops processes, strategies, and structures that enable them to learn and react effectively in uncertain and dynamic environments' (Schechter & Mowafaq, 2012).

Since its widespread recognition (1990), the evolution of the concept and model over the course of almost three decades has undergone developments, either in the direction of learning at all levels (individual, team, organizational), as suggested by Watkins and Marsick (1996), or in the direction of management practices and organizational policies in defining the learning strategy, such as those proposed by Goh (1998) and by Garvin, Edmondson, and Gino (2008).

Because the pressures in the educational area have been increasingly high, especially for correlating the expected learning outcomes with explicit labor market demands (in order to reduce the distance between the competences graduates have at the end of schooling and those demanded by employers) and with requirements that the companies are constantly and rapidly changing (in terms of graduates' transversal skills – value acquisitions and attitudes that go beyond a specific field/study program, such as autonomy, responsibility, social interaction, personal development, creativity), the models originally proposed for schools as learning organizations (centered on mutual learning and peer collaboration within the same school) have expanded, including networking and collaboration beyond school boundaries, as well as strategic leadership (as a condition to create an organizational culture of learning and to encourage organizational learning).

Analyzing the models and their outcomes proposed and adopted punctual by some school communities and educational systems (as in the case of the Netherlands, which with its Teachers Agenda 2013–2017 introduced the transformation of schools into learning organizations as one of its main objectives) for about 25 years, Kools & Stoll proposed a last model (2017) for re-conceptualizing the school as a learning organization, adapted to the contemporary educational context, based on the one proposed and extended by Watkins and Marsick (1996), with seven specific dimensions – (1) continuous learning, (2) inquiry and dialogue, (3) team learning, (4) embedded system, (5) empowerment, (6) system connection and (7) strategic leadership. This approach is intended to be a starting point in the unitary understanding of the SLO concept for all stakeholders (decision-makers, teachers, parents, employers, local communities), focusing on seven action-oriented 'dimensions:' (1) developing and sharing a vision centered on the learning of all students; (2) creating and supporting continuous learning opportunities for all staff; (3) promoting team learning and collaboration among all staff; (4) establishing a culture of inquiry, innovation and exploration; (5) embedding systems for collecting and exchanging knowledge and learning; (6) learning with and from the external environment and larger learning system; (7) modeling and growing learning leadership.

Its advantage lies, among others, in providing key characteristics (key features) for each of the seven directions of action through the guide entitled 'What makes a school a learning organization? A guide for policy makers, school leaders and teachers' (OECD-UNICEF, 2016). It, therefore, offers the possibility to measure and establish both the starting level and the degree of transformation after a certain period and a series of taken steps. For this reason, the Government of Wales considered the development of schools as learning organizations a key means for realizing its new curriculum, by designing a Wales' SLO model through a process of co-construction together with an assessment methodology (in 2017) and developing a first assessment process (OECD, 2018).

In Romania, the general concept and model of learning organization have very few approaches that exceed the theoretical level (using a specific assessment methodology and measurement tools in order to determine incidence of certain key characteristics), directed either towards the public administration (26 County Councils) or towards business (large pharmaceutical companies or SMEs).

Research Methodology

Methodologically, in order to answer to the first research question, a first desk research analysis was developed on: (1) the public expenditure in education and per capita funding for the 2009–2018 period, (2) the enrollment evolution from 2006 to 2016 and (3) the results of PISA evaluations for the 2006–2015 period.

The data collection process for this first step relies on:

- the national laws for approving the annual general budget execution account, the annual budget execution account of the Single National Health Insurance Fund and the annual general government debt account, approved by governmental decisions, for the whole period 2009–2017; data for 2018 are not yet available, as, according to the national calendar law's project for the previous year, it is due to enter into consultation in June 2019;
- the annual governmental decisions on approving the methodological norms to determine the standard cost per student, taken annually for the next calendar year, for the period 2010–2018;
- the statistics provided by the National Institute of Statistics (Institutul National de Statistica, 2016) regarding the evolution of enrollment in the pre-university segment of education from 2006 to 2016, and its estimates till 2030 and 2060;
- data provided by the OECD regarding PISA mean scores in mathematics, science and reading, together with the share of low achievers in each of these fields, for the period 2006–2015, in Romania.

Subsequently, in order to answer to the second research question, a second desk research analysis was developed on correlations between the seven action-oriented dimensions of the SLO model proposed by Kools & Stoll (2017) (including their key characteristics/elements provided into the OECD-UNICEF guide) and the performance indicators (including descriptors) that are used at the Romanian national level as a way to establish the quality of the educational services provided by pre-university school organizations (along with other legal regulations in force at the national level).

The correlation process for this second step relies on the analysis performed on:

- key characteristics (key features) of the SLO model provided by the guide ‘What makes a school a learning organization? A guide for policy makers, school leaders and teachers;’
- the descriptors provided by Government Decision no. 1534/2008 regarding the approval of the reference standards and performance indicators for the evaluation and quality assurance in pre-university education.

Each of the 49 key characteristics provided in the guide was compared with the requirements expressed by the 96 descriptors, regardless of the performance indicator under which they were located. Additional comments were developed taking into account a qualitative analysis of the strategies for education in Romania, as well as the legal regulations in force regarding continuous training of teachers or findings regarding continuous training of teachers.

Results

The State of Affairs at the Romanian Educational System (the Pre-University Level)

On the background of the international economic crisis of 2008–2015, the effects have been felt in Romania already in 2009. In 2010 the government had to take some of the toughest austerity measures: cutting public wages by 25%, lowering social benefits by 15%, and increasing VAT from 19% to 24%. The effects have also been felt at the educational system level: in 2017 the level of payments made in education hardly reached and exceeded the level of 2009. However, a constant decrease of public expenditure in education could be observed: from 5.76% of total expenditures in 2009 to 3.76% of total expenditures in 2017 (Table 1 presents the evolution of public expenditure in education for the period 2009–2017 in Romania).

During the whole period 2000–2009, the financing mechanism based on historic costs was in place; because significant differences were identified between the average costs incurred and the historical costs per pupil, between 2003 and 2009 several pilot projects were carried out aimed to define more rigorously a financing formula. Starting from 2010, a new per capita financing mechanism was completely implemented. Therefore, the analysis will only refer to the implementation period of this funding mechanism, i.e., 2010–2018. In the beginning it was used only to finance salary

Table 1 Romania's Public Expenditure in Education, 2009–2017 Period, Expressed in the National Currency (ROL)

Year	Expenditures made, expressed in ROL		Share in total expenditure
	Total value	of which, in education	
2009	89,851.7	5,176.3	5.76 %
2010	102,627.7	4,315.2	4.20 %
2011	106,088.7	4,207.6	3.96 %
2012	104,569.8	3,993.9	3.81 %
2013	110,128.0	3,867.2	3.51 %
2014	115,615.9	4,442.4	3.84 %
2015	125,215.8	4,491.9	3.58 %
2016	130,083.1	5,040.0	3.87 %
2017	144,418.8	5,430.2	3.76 %

Notes Calculations based on the Romanian Laws for approving the annual general budget execution account, the annual budget execution account of the Single National Health Insurance Fund and the annual general government debt account, approved by governmental decisions (http://www.mfinante.gov.ro).

costs but, with the new education law and related regulations (means starting from 2012), the new funding mechanism covers all basic expenses (including non-wage costs).

According to the national education law and its related regulations, the basic financing of pre-university education takes into account the principle of 'the financial resource follows the student,' based on which the student's budget allocation is transferred to the school unit he/she is learning. The financing of State pre-university schools includes: (1) a core funding (covering salary costs and related contributions), determined from the standard cost per pupil, multiplied by the specific correction coefficients (for the temperature area, special education, education in minority languages) and by the number of pupils enrolled; and (2) a complementary funding (covering continuous training and staff evaluation, student's assessment, expenditure on material goods and services), determined as a coefficient of the reference value (defined for a standard student, considered to be the student in the gymnasium schooling level, the urban environment), which means it is also correlated with the standard cost per pupil. Therefore, at funding level, a component for the continuous training of teachers is provided. The advantages of this per capita financing mechanism were evident at a first stage, establishing a balance between budgetary projection and budget execution, but now its limits have begun to become increasingly obvious, as it is not geared towards performance indicators and results. As a result, more numerous situations requiring corrections have come to light, especially for schools in disadvantaged socio-economic areas.

Table 2 The Standard Cost per Student in Romania, Expressed in ROL

Year	Pre-school education (short program)		Pre-school education (prolonged program)		Primary education	
	(1)	(2)	(1)	(2)	(1)	(2)
2010	1.895	2.071	3.474	3.474	2.180	2.597
2011	1.478	1.617	2.712	2.712	1.701	2.027
2012	1.478	1.617	2.712	2.712	1.701	2.027
2013	1.605	1.755	2.943	2.943	1.847	2.200
2014	1.653	1.807	3.031	3.031	1.902	2.266
2015	1.671	1.827	3.065	3.065	2.520	2.898
2016	2.018	2.206	3.700	3.700	2.322	2.766
2017	2.480	2.712	4.548	4.548	2.854	3.400
2018	2.926	3.200	5.367	5.367	3.368	4.012

Continued on the next page

The evolution of per capita financing was influenced by the international economic crisis that affected Romania. For instance only in 2016 the level of standard cost per student exceeded the level of 2010 (Table 2 presents the evolution of the standard cost per student, for the 2010–2018 period in Romania), reflecting to a large extent the retroactive recognition of teachers' salary rights. Although in the last 3 years there has been an increase in the absolute value of per capita funding in all segments, this must be seen in the general context of a revision of the salary grid since August 2016.

Despite increases, in fields as pre-school and primary education (essential to combat early school leaving and to ensure a start in life on equal terms) spending remains below the EU average (0.7% compared to 1.5% of GDP in EU-28), a fact highlighted by The Education and Training Monitor Report 2018 Romania (European Commission, 2018), along with the need to optimize costs in education, while also improving equity, especially in the context of the sharp drop in the number of pupils. In this regard, according to the latest national statistics provided by the Romanian Institute of Statistics (Institutul National de Statistica, 2016) from 2006 to 2016, the total number of pupils decreased by 17%, 20% in pre-school education and by 13% in schools (pre-university education), and will continue to decrease. The estimates at a general level are of 16.56% by 2030 (and of 42.5% by 2060), at pre-school level of 21.43% by 2030 (and of 45.4% by 2060) and at primary level of 19.78% by 2030 (and of 44.1% by 2060), all compared to the 2014–2015 school year (Institutul National de Statistica, 2016).

In terms of PISA assessments, between 2006 and 2012 Romania showed a slight improving trend in all 3 fields (mathematics, science and reading) and in making progress towards reducing the share of low achievers. But in 2015, Romania took a step backwards compared to 2012,

Table 2 *Continued from the previous page*

Year	Gymnasium education		High school theoretical education		Technological high school education	
	(1)	(2)	(1)	(2)	(1)	(2)
2010	2.857	3.494	2.713	2.713	2.953	2.953
2011	2.230	2.727	2.119	2.119	2.306	2.306
2012	2.230	2.727	2.119	2.119	2.306	2.306
2013	2.420	2.783	2.420	2.420	2.503	2.503
2014	2.492	2.866	2.492	2.492	2.577	2.577
2015	1.021	1.210	2.520	2.520	2.606	2.606
2016	3.043	3.499	3.043	3.043	3.146	3.146
2017	3.740	4.301	3.740	3.740	3.868	3.868
2018	4.413	5.075	4.413	4.413	4.564	4.564

Notes Column headings are as follows: (1) urban area, (2) rural area. Calculations based on the annual Government Decisions on approving the methodological norms to determine the standard cost per student.

Table 3 Romania's Results in PISA Evaluation, 2006–2015 Period

Year	Mathematics		Science		Reading	
	(1)	(2)	(1)	(2)	(1)	(2)
2006	415	52.7	418	46.9	396	53.5
2009	427	47.0	428	41.4	424	40.4
2012	445	40.8	439	37.3	438	37.3
2015	444	39.9	435	38.5	434	38.7

Notes Column headings are as follows: (1) mean, (2) percentage. Calculations based on PISA 2015, 2012, 2009 and 2006 results (see https://www.oecd-ilibrary.org/education/pisa_19963777).

as most of EU countries, in reducing the share of low achievers in science and reading, being still far from the 2020 benchmark (by 2020, the share of low-achieving 15-year olds in reading, mathematics and science should be less than 15%). Although, in relation to its own performance, Romania has evolved positively, compared to the performance of other EU countries, there are considerable differences, with a long position behind them (Table 3 presents the PISA mean scores in mathematics, science and reading, altogether with the share of low achievers in each of these fields, for the 2006–2015 period). Although it is clearly stated that PISA cannot identify cause-effect relationships between inputs, processes and educational outcomes, this kind of evaluation reveals the 15-year-old students performances in mathematics, science and reading, allowing all interested parties to identify the state of affairs at national level, to monitor national trends over the years and to compare them with performances in other countries.

In this general context, taking into account the transfer of the last year of kindergarten to primary education (in 2012) and the evolution of Romania's results in the PISA evaluation, a reshaping of the curriculum for pre-school and primary education was decided. As a result, Romania has begun the implementation (between November 2017 and November 2021) of the national project CRED ('Relevant Curriculum, Open Education for All'), funded by the ESF (42 million euros) to support the reform of the current school curricula, aiming to facilitate the understanding of the new skills-based curriculum, focused on students, as well as to modernize teaching practices.

The Correlations Between the SLO Model Proposed by Kools & Stoll and the Romanian Performance Indicators

The analysis is conducted taking into account: (1) all seven action-oriented dimensions of the SLO model proposed by Kools & Stoll (2017) and their key characteristics/features provided in the guide 'What makes a school a learning organisation? A guide for policy makers, school leaders and teachers' (OECD-UNICEF, 2016); (2) all the 43 performance indicators (including descriptors) that are used at the Romanian national level in order to establish the quality of the educational services provided by pre-university school organizations (provided in Government Decision no. 1534/2008), as well as other legal regulations in force at the national level regarding continuous training of teachers and findings regarding continuous training of teachers.

Dimension 1: Developing and Sharing a Vision Centered on the Learning of All Students

Developing and sharing a vision centered on the learning of all students, common for all school organizations, involves two elements – to have a public policy at the national level (a national strategy) directed towards it with leaders able to attract staff into creating such a vision, communicating this vision to others, and making people (through their own example) enforce it altogether.

Regarding the first element, and since 2014, five sector strategies for education have been designed, approved by Government Decisions and developed – (the National Strategy for Research, Development and Innovation 2014–2020, the National Strategy for Tertiary Education 2015–2020, the National Strategy for Lifelong Learning 2015–2020, the Strategy to reduce early school leaving in Romania and the Strategy of education and training in Romania for the 2016–2020 period). However, none of them explicitly and directly addresses the focus on student learning. Regarding the second element, although the proposal for the school development plan is initiated by the teaching staff and students, parents and local councils are invited to participate (this aspect being checked and analyzed as a basic condition in national standards, along with the way it embraces the vision and mission of the school). At this point, nonetheless, without an in-depth analysis (at staff level), it is not clear whether the vision is explicitly centered on the learning of all students and to what extent we have to deal with managers or with leaders. Nevertheless, one single performance indicator (I27, Achieving the curriculum) has descriptors referring to focusing on students, namely 'Teachers develop students' ability to learn from experience and practice' and 'Teachers systematically apply student-centered teaching methods and group-based teaching methods.' Therefore, this could be relatively correlated with one key characteristic of the 1st dimension, namely 'Learning and teaching are oriented towards realizing the vision.' As a result, at this point, a strait correlation of this dimension with the national performance indicators cannot be concluded.

Dimension 2: Creating and Supporting Continuous Learning Opportunities for All Staff

From a general systemic perspective, Romania has a well-defined legal framework that supports lifelong learning (made up of laws on education, apprenticeship, internships, volunteering and adult vocational training) that refers either to initial training or to continuous training, including teachers. The participation of teachers in professional development programs is mandatory in order to remain in the profession, recommending them to obtain at least 90 transferable professional credits every five years.

A relatively recent report on monitoring and implementation of education strategies, entitled 'Teaching Staff – SABER Country Report' and delivered under the Agreement on Technical Assistance Services for the Ministry of National Education (concluded between the Ministry of National Education and the International Bank for Reconstruction and Development), highlights three things in terms of supporting teachers to improve the educational process (World Bank Group, 2017, p. 17): (1) 'the professional development of teachers includes activities that have been found to be associated with the improvement of the instructive-educational process' (observation visits, networks of teachers, networks of schools and mentoring/individual guidance), although 'in practice, most of them do not have the expected impact;' (2) 'teachers are advised to take part in professional development activities lasting at least 360 hours over a five-year period,' but 'if they do not accumulate these credits over the five-year period, there are no repercussions' once the final entry stage in the educational system has been exceeded (i.e., once they become permanent teachers); (3) although in some cases teacher needs analysis is carried out (at school level) and the results are transmitted to the county authorities, 'most of the training courses addressed to the teachers do not take into account these analyzes and are

Table 4 Correlations between Underlying Characteristics of 2nd Dimension and Performance Indicators (Including Descriptors)/Or Legal Regulations in Force at the National Romanian Level

Underlying characteristics of 2nd dimension	Performance indicators (and descriptors)/other legal regulations
All staff engage in continuous professional learning	Participation of teachers in professional development programs is mandatory in order to remain in the profession
New staff receive induction and mentoring support	Mentoring/individual guidance is one of the professional development activities officially recognized and provided to new staff at national level
Professional learning connects work-based learning and external expertise	*Indicator 30: Scientific activity of teachers* Teachers participation in the scientific research activity carried out by the school or at local, regional, national or international level it has grown in number and percentage
	Indicator 31: Methodological activity of teachers Teachers participation in the methodological activities carried out at local level – with demonstration activities, presentations etc. – it has grown in number and percentage
	Indicator 36: Professional development of staff The application in teaching activities of the participation's results in continuous training and professional development programs is systematically monitored The application in teaching activities of the participation's results in methodological and scientific activities is systematically monitored
Professional learning is based on assessment and feedback	*Indicator 36: Professional development of staff* Observing the current activity and the feedback received from the relevant beneficiaries are used for the review of the professional development plans
	Indicator 39: Teaching staff evaluation The assessment of the teaching staff is based on feedback from relevant stakeholders The assessment of the teaching staff includes recommendations on further professional development
Time and other resources are provided to support professional learning	At the funding level, the financing of State pre-university schools includes a component that can be used for student's assessment, for expenditure on material goods and services and for the continuous training of teachers (either according to institutional needs or according to the individual needs of the staff).

Notes Based on underlying characteristics provided in the OECD-UNICEF's guide (2016), on performance indicators for quality assessment and quality assurance in pre-university education provided in Government Decision no. 1534/2008 and on legal regulations in force at the national level.

not based on the pupils' school results or on the observations made during the school inspections.' The report also includes a number of policy recommendations, among which: (1) 'introducing individual guidance (coaching) and ensuring that it goes beyond just checking the teacher's compliance with administrative instructions;' (2) 'improving ongoing training programs to support debutants;' (3) 'setting up the training courses in which the teacher participates according to his/her needs, as well as establishing the teachers who have to take part in the courses as a priority, following the needs identified during the evaluations' (World Bank Group, 2017, pp. 24–25). From a more nuanced perspective, considering the nine key features (underlying characteristics) proposed by the OECD-UNICEF's guide (OECD-UNICEF, 2016), it results that only five of them could be correlated at this point with performance indicators (and descriptors) or with other legal regulations in force at national level (Table 4 presents this correlation).

However, some comments are needed:

1. Regarding the participation of teachers in professional development programs – once the final entry stage in the educational system has been exceeded, the recommendation to obtain at least 90 transferable professional credits every five years remains rather an incentive system to promote in the teaching career or to gain access to leading positions (school principal, or school inspector);
2. Regarding mentoring/individual guidance for new staff – even if this training method is used, its quality needs improvement;
3. Regarding resources provided to support continuous training of teachers – they must bear some of the costs of professional training (which is one of the reasons why teachers do not get a minimum of 90 credits once the final entry stage in the educational system has been exceeded) because the financing component that includes continuous training of teachers may be used for multiple purposes (continuous training and staff evaluation and/or student's assessment and/or expenditure on material goods and services).

For the 3rd Dimension (Promoting team learning and collaboration among all staff), for the 4th Dimension (Establishing a culture of inquiry, innovation and exploration) and for the 7th Dimension (Modelling and growing learning leadership), no correlation could be found at this time between underlying characteristics provided in the OECD-UNICEF's guide (OECD-UNICEF, 2016) and performance indicators or legal regulations in force at the national level.

Dimension 5: Embedding Systems for Collecting and Exchanging Knowledge and Learning

Considering the eight key features (underlying characteristics) proposed by the OECD-UNICEF's guide (OECD-UNICEF, 2016), it results that three of them could be correlated at this point with performance indicators (and descriptors) at the national level (Table 5 presents this correlation).

Table 5 Correlations between Underlying Characteristics of 5th Dimension and Performance Indicators (Including Descriptors) at the Romanian National Level

Underlying characteristics of 5th dimension	Performance indicators (and descriptors)
Systems are in place to examine progress and gaps between current and expected impact	*Indicator 28: Evaluation of pupils' school results* Each teacher can describe for each group and student the strengths and weaknesses regarding the achievement of the curricular objectives
The school development plan is evidence-informed, based on learning from self-assessment, and updated regularly	*Indicator 37: Revision of the educational offer and of the development plan* The benchmarking is used to optimize the educational offer and the development plan The staff and relevant stakeholders are involved in reviewing the educational offer and the development plan
The school regularly evaluates its theories of action, amending and updating them as necessary	*Indicator 34: Existence and implementation of institutional self-evaluation procedures* The results of self-evaluation and external evaluation are used to plan, carry out and review the quality assurance and improvement activities and procedures

Notes Based on underlying characteristics provided in the OECD-UNICEF's guide (2016) and on performance indicators for quality assessment and quality assurance in pre-university education provided in Government Decision no. 1534.

Dimension 6: Learning with and from the External Environment and Larger Learning System

Considering the seven key features (underlying characteristics) proposed by the OECD-UNICEF's guide (OECD-UNICEF, 2016), it results that three of them could be correlated at this point with performance indicators (and descriptors) at the national level (Table 6 presents this correlation).

Conclusions and Further Developments

The results of this theoretical approach (desk research analysis) show that in last decade the pressure on the Romanian educational system has been high, with schools from the pre-university segment being subjected to financial constraints, as well as systemic architectural design changes, curricular changes and the decline of the school population. In addition, the results of the PISA tests were not encouraging: in 2015 Romania took a step back in all 3 fields compared to 2012 and in reducing the share of low achievers in science and reading, being still far from the 2020 benchmark.

The financial constraints highlighted by the evolution of education expenses and per capita financing have meant not only the reduction of salaries and expenses for the continuous professional training of teachers, but also the reduction of investments. In addition, the change of educational architectural design in 2012 (transferring the last year of kindergarten to primary education, along with curriculum reshaping) and the decline of the

Table 6 Correlations between Underlying Characteristics of 6th Dimension and Performance Indicators (Including Descriptors) at the Romanian National Level

Underlying characteristics of 6th dimension	Performance indicators (and descriptors)
The school is an open system, welcoming approaches from potential external collaborators	*Indicator 3: The existence and functioning of the internal and external communication system* The school systematically communicates with parents and other stakeholders
The school collaborates with parents/guardians and the community as partners in the education process and the organization of the school	*Indicator 1: The existence, the structure and the content of the projective documents (development plan and implementation plan)* Aims, objectives and programs established at the request of relevant stakeholders are included in the development plan and in the implementation plan
	Indicator 32: Setting up the school budget The school ensures the involvement of community partners and relevant stakeholders in budget planning
	Indicator 34: Existence and implementation of institutional self-evaluation procedures The self-evaluation procedures are carried out with the participation of relevant stakeholders
Staff collaborate, learn and exchange knowledge with peers in other schools through networks and/or school to-school collaborations	*Indicator 30: Scientific activity* Teachers capitalize on teaching the results of the scientific research activity carried out at local, regional, national or international level
	Indicator 31: Methodological activity Teachers capitalize on teaching the results of the methodological activities carried out at local level

Notes Based on underlying characteristics provided in the OECD-UNICEF's guide (2016) and on performance indicators for quality assessment and quality assurance in pre-university education provided in Government Decision no. 1534.

school population (by 20% in pre-school education and by 13% in schools) mean that neither the 2015 results on PISA tests, nor the negative evolution of the schools efficiency, as it was identified at 64.7 % from 2,956 of school organizations (out of a total of 6,413 schools with legal personality that formed the national school network in 2017–2018), were surprising.

Therefore, finding solutions to help increase the efficiency of school organizations is more than needed at the national level. Since at teachers' level the implementation of the new curriculum (skills-based, focused on students) is supported by the CRED project, another course of action to gain focus on students, but at the organizational level, would be the reconceptualization of schools using the SLO model and concept. In this way, focusing on students would be likely to become both a teaching and learning practice, as well as on a vision of school organizations shared by all their members, the implementation of the model and concept could become on opportunity to embrace it from both sides, individual and organizational.

Implementing the concept could have as a foundation and starting point 10 performance indicators (out of 43) and 17 descriptors (out of 96) from national standards identified as being correlated with 3 dimensions (out of 7) and 8 underlying characteristics (out of 49) from the SLO model developed by Kools & Stoll (2017) and OEDC-UNICEF (2016), as well as the legal regulations in force regarding continuous training of teachers.

In the first instance, the correlation results will be used in an experimental research (a quantitative and qualitative analysis), on a sample of 238 rural and urban schools externally evaluated in the first semester of the 2018–2019 school year, in order to determine the minimum levels of incidence of the underlying characteristics of SLO's. This will provide a preliminary overview on the state of affairs at the Romanian educational system level in relation to the model of SLO's.

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The Mediating Effect of Skills Application on the Relationship between Learning and Continuous Improvement

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Perceived urgency for the upskilling of employees is rapidly increasing within political, social, and economic institutions. This brings the danger that companies invest in training and development of employees without understanding its effects in order to enjoy sustainable learning in the workplace. This study explored the mediating role of skills application in the relationship between learning and continuous improvement in a knowledge-intensive company. An employee survey from 2015 of a knowledge-intensive company with a sample of 3,730 employees was utilized to perform mediation analysis with structural equation modelling through the bootstrapping method. The analysis confirmed that learning affects continuous improvement by affecting skills application. The investigated effects are statistically significant and positive. The results provide empirical support on the mediating role and the importance of skills application to see the benefits of learning measures in the workplace. This research is relevant for knowledge-intensive organizations as a way to understand that learning activities in the workplace alone are not sufficient to influence continuous improvement of processes, products, and better ways of working.

Keywords: human capital, in-company training, sustainable learning, continuous improvement

Introduction

Learning in the workplace is not a temporary fashion of the last decades, but a product of continuous development (e.g., Marshall, 1925; Taylor, 1911). With the rise of modern industrial enterprises, the demands on the skills of employees have become more complex, while companies have become increasingly interested in developing the workforce under their directions. For example, in 1871, the American printing press manufacturer R. Hoe & Company built its school within its factory. Some years later, General Electric (GE) established practical training and educational courses for the apprentices (Wright, 1908). Since the 1920s, learning in the workplace is no longer a rarity for German companies such as Siemens, AEG, or Thyssen (Büchter, 2002; Pawlowsky & Bäumer, 1996). In the meantime, not only the world of work but also workplace learning has changed fundamentally in its practical manifestations under constant pressure from globalization, technological progress, international standards and political agendas (World Economic Forum, 2019). In the 1920s, only job-specific training of the employees was the focus of companies, whereas today it also includes general training. Not only employers but also employees themselves think that it is crucial to get training to be in step with changes in the workplace (World Economic Forum, 2016). The absence of a discussion on investment in human capital in the beginning of 20th century is an interesting fact, which shows how companies were acting with respect to the development of knowledge, skills, and competencies of their employees, but in contradiction with theoretical foundations that considered human capital as a factor to be minimized and not as a source of competitive advantage (Coase, 1937; Gutenberg, 1998). Gutenberg (1998) described the firm as a production function and wholly ignored the human factor like competencies, skills, and knowledge. Production for him was the essence. Employees are the costs in his production function, and each enterprise strives for maximisation of return on invested capital. Human capital did not receive any attention in Coase's (1937) argumentations either. Only in the second half of the 20th century, the Chicago School representatives, such as Mincer (1962, 1975), Schultz (1959, 1960, 1972) and Becker (1993), integrated the Human Capital Theory into economic analysis. However, the Human Capital Theory aligned on assumptions of neo-classic theory, such as perfect competition, and therefore has limitations for current conditions (Acemoglu & Pischke, 1998). Today, acquisition of human capital does not end with education in school, at university, or in apprenticeship programs, companies also invest in the general training of their employees. The top 5 training segments sourced on the market in 2014 were training related to Information Technology (IT), Leadership, Learning Technologies, Sales, and Content Development (Harward, 2014). It is estimated that corporations spent around 362 billion US dollars in 2017 on corporate training activities worldwide (Statista, 2018). For example, Boeing announced in 2017 an investment of '$100 million for workforce development in the form of training, education, and other capabilities development to meet the scale needed for rapidly evolving technologies and expanding markets' (Boeing, 2017). A recent study by the Capgemini Research Institute among organizations with high automation maturity revealed that organizations that offer full-scale training to their employees enjoy a higher level of employee productivity. Also, upskilling supports career progression, boosts employee morale, and the workforce is more supportive to carry out new responsibilities (Crummenerl, Buvat, Ghosh, Yardi, & Khadikar, 2018). The existing empirical research focused more on direct relations between in-company training or learning and dependent variables such as performance, productivity, innovation, morale, quality (e.g., Sisyuk, 2018). In this study, the mediating variable 'skills application' is included to achieve a better understanding of learning in the workplace and its impact on continuous improvement, which is defined as a latent construct.

Next, the paper presents a review of the theoretical and empirical concepts of learning, skills application, and continuous improvement in the workplace. It is followed by a methodological approach, which includes the determination of the theoretical model and hypotheses to be tested empirically. Results of the performed empirical analysis, their discussion, research limitations, and recommendations for future research are provided at the end of the paper.

Literature Review

Learning and skills Application as an Aspect of Human Capital

The importance of learning in workplace was recognized by Taylor (1911) who stressed that 'the most important object of both the workmen and the management should be the training and development of each individual in the establishment, so that he can do (at his fastest pace and with the maximum of efficiency) the highest class of work for which his natural abilities fit him' (p. 70). However, the rationales and impact of investment in some components of human capital such as training were explained theoretically and empirically with works of the Chicago School of Economics representatives of the Human Capital Theory (Becker, 1993; Mincer, 1962, 1975; Schultz, 1959, 1960, 1972). Later, the representatives of the Organizational Learning Theory, Argyris (1995) and Senge (1990), contributed with their work to the concept of 'learning organization.' The core of this concept is to enlarge people's capacity to accumulate intellectual capital and to work productively towards organizational target achievement.

Learning in the workplace may occur in different forms: on-the-job and off-the-job, formal and informal (Kauffeld, 2010). Organizations, especially with integrated learning and development departments, are aligning with the 70:20:10 formula to define a balance for learning and development activities in the workplace. For instance., Siemens AG. 70 means that 70% of development takes place on the job as part of the daily work activities; 20 describes that 20% of development occurs through feedback, through working with others and through seeing good and bad examples; 10 stands for 10% of development, which happens through formal training and development activities (Hartwig, 2012). Nevertheless, the origin of the 70:20:10 formula is quite mysterious. Some of the publications on the 70:20:10 formula cited sources from Lombardo and Eichinger (1996) and McCall, Lombardo, and Morrison (1988). McCall et al. (1988) emphasize the importance of learning from experience in the context of executive development. They surveyed 191 successful executives to understand the reasons for their success. In addition, they mentioned the lack of research on the impact of classroom training, as well as on-the-job training. Lombardo and Eichinger (1996) published results on a survey of successful executives done earlier by McCall et al. (1988). The findings are that successful executives learned roughly 70% from challenging jobs, 20% from other people, and 10% from training courses and reading. The 70:20:10 formula as an anchor for training and development in the workplace did not appear in those two sources. Furthermore, the study by Clardy (2018) found that the evidence for 70:20:10 is weak and suggested to revise the 70% rule of informal learning in spite of its application in practice. He also opted for redefining the focus of formal and informal work-based learning. Kajewsky and Madsen (2014) stated: 'there is a lack of empirical data supporting 70:20:10 and [...] there is also a lack of certainty about the origin' (p. 3). The newest report published by Training Industry (2018) claimed the 70:20:10 formula and referred to the 55:25:20 model. The proposed ratio represents the amount of learning from on-the-job training, social interaction, and formal training activities.

Regarding the definition of learning in the workplace, the OECD (2002) offered the following one: 'Job-related continuing education and training refers to all organized, systematic education and training activities in which people take part in order to obtain knowledge and/or learn new skills for a current or a future job, to increase earnings, to improve job and/or career opportunities in a current or another field and generally to improve their opportunities for advancement and promotion' (pp. 7–8). There are various other definitions, such as 'Training – the planned and systematic modification of behaviour through learning events, programs and institutions that enables individuals to achieve the levels of knowledge, skills and competence needed to carry out their work effectively' (Armstrong, 2011, p. 249). In alignment with definitions, workplace training aims to improve knowledge, skill, etc. and its applications in return to improve performance, which can be defined depending on the context. Thus, skills application is related to the ability to apply acquired knowledge (North, Reinhardt, & Sieber-Suter, 2018). In line with the research question, the focus lies on learning at the workplace, which takes place through in-company training, experience, etc., and which leads to the accumulation of human capital in the form of skills and, consequently, its application.

Continuous Improvement and How it is Defined

Imai (1992) brought Total Quality Management (TQM), Quality Circle, Lean Management, Kamban, Zero-Defect Strategy, Productivity Improvement, Just-in-Time Production into one easy-to-understand concept: Kaizen. He characterizes 'Kaizen' as a continuous improvement by summing up individual ideas involving all employees from all areas of an organization. Kaizen starts from the realization that there is no organization without problems, and no day should pass without any improvement in the organization: every product, every process, every activity can still be improved. However, Kaizen is not a Japanese invention, but the guiding principle of evolution 'survival of the fittest,' which runs in small steps and whose engine is in constant competition and in a constant struggle for the best possible adaptation (Darwin & Wallace, 1858). In the Western world, Kaizen is referred to as 'Continuous Improvement Process' (CIP) and means 'improvement of quality and productivity, continuously and consistently in small steps, so that the customer is sustainably satisfied' (Kostka & Kostka, 2008, p. 12). The continuous improvement of the processes means for all members of the organization, on the one hand, to continually learn, to be adaptable to changing requirements, and, on the other hand, to continually improve what already exists. Here, the customers are an essential orientation because they decide on the quality of the products and services (Imai, 1992). For example, Toyota has created the principle 'Do the right thing for the company, its employees, the customer, and society as a whole' (Liker, 2004, p. 72) The customer is at the heart of Toyota's organizational goals, and its needs are placed at the beginning of the product development and production process. The first question in the Toyota Production System is: 'What does the customer expect from this process?' (Ohno, 1988, pp. 8–9). It is continually trying to improve the quality of the process since the quality assurance of the process ensures the quality of the finished product. The focus of this research is continuous improvement expressed through new ways of working, process improvement, and innovation.

Empirical Studies

After Mincer (1962, 1975), Schultz (1959, 1960, 1972) and Becker (1993) laid its foundation, numerous scientists have dealt with human capital theory and investigated the impact of investment in learning activities in the workplace (e.g., on-the-job, off-the-job training). The main focus of empirical studies before the 1990s was on the analysis of the effects of in-company training on wages and productivity.

From 1990, the number of studies analyzing the wage effects decreased. Instead, the studies dwelled upon the effects of training on performance, fluctuation, promotion, knowledge, skills, quality, safety, and other variables gained in importance. However, the empirical analysis has been treated very differently by scientists, and their studies vary concerning their data sources, variable definitions, methodology, effects, and even partly contradict one another. The review of 267 empirical studies conducted by Sisyuk (2018, 2019) provides an overview of data sources, independent and dependent variables utilized in those studies, as well as the measured empirical effects. Among those studies,15 studies used innovation, quality, and customer service as dependent variables (e.g., Dostie, 2014; Shen & Tang, 2018). No empirical study that examined the relationship between learning and continuous improvement by utilizing the mediation role of skills application by focusing on a knowledge-intensive company could be found. There is also a limited number of studies exploring the non-linear relationship between independent and dependent variables by involving mediating variables.

'The Knowledge Ladder' from North and Kumta (2018) showed theoretically that learning, skills application and performance or task achievement are connected, therefore, this model may also be utilized to test the relationship between learning, skills application and continuous improvement as continuous improvement aims to enhance business performance, and enhancement of business performance is what companies strive for.

Research Model and Hypotheses

The Human Capital Theory (e.g., Becker, 1993) on investment in training did not consider 'in-company training' as a construct and did not measure it through indicators. It considers training as an input factor and measures its effects on some of the output factors, such as productivity or performance. Various empirical studies proved a positive relationship between training and productivity, performance, and other variables. However, the number of studies exploring the role of mediating variables between training and an independent variable is quite yet limited (Sisyuk, 2018, 2019). North and Kumta (2018) derived 'The Knowledge Ladder' based on the constructivism theory. It visualizes clear interrelations for terms like symbols, data, information, knowledge (know what and why), action (know-how), competence and competitiveness and shows, for example, how information gained in training is related to knowledge, skills application or concrete outcome. The model for this research is developed based on 'The Knowledge Ladder' to demonstrate a relationship between in-company training, skills application, and continuous improvement. The indicators of the latent construct 'continuous improvement' are derived based on the literature review.

The overall objective of this research is to improve our understanding of the impact of learning in the workplace. Consequently, the hypotheses to be tested are formulated as follows:

H1 *The relationship between learning and continuous improvement is positive and significant.*

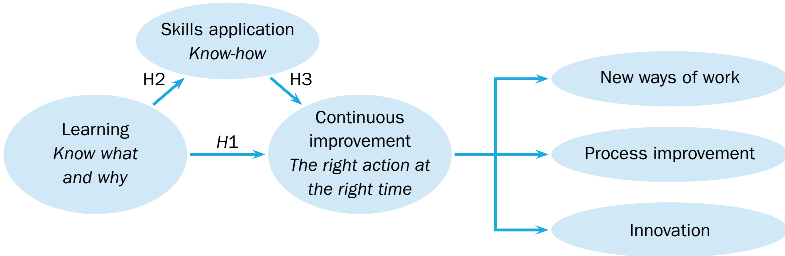

Figure 1 Research Model (developed based on North and Kumta, 2018; Ohno, 1988)

- H2 *The relationship between learning and skills application is positive and significant.*
- H3 *The relationship between skills application and continuous improvement is positive and significant.*
- H4 *Impact of learning on continuous improvement through skills application is significantly stronger than the direct effect of learning on continuous improvement.*

Methodology

Quantitative data from an employee survey of an operational unit of a knowledge-intensive company were analyzed to test the defined hypotheses. This survey was conducted in 2015 with a response rate of approximately 65%, which led to a sample of 3,730 employees. Participants were asked to rate survey statements using a five-point Likert scale of how much each statement applies (from 'agree' to 'disagree'). Table 1 summarizes the selected survey items that empirically represent the variable 'learning,' 'skills application,' and hypothetical construct 'continuous improvement,' and that were processed for further analysis.

The variable 'learning' was measured within the survey as follows:

- Only on-the-job and off-the-job training measures initiated and paid by current employer exclusively.
- Only on-the-job and off-the-job training measures received during employment by the current employer.

The variable 'skills application' measured was based on whether the employees are applying what they learn, what they know, and what they are capable of in their daily jobs and whether the organization gives them the possibilities to apply their skills.

The variable 'continuous improvement' measured through employee participation in continuous improvement by using new ways to approach chal-

Table 1 Variables 'Learning,' 'Skills Application' and Latent Construct 'Continuous Improvement'

Variable (construct/indicator)		Survey statement
Learning	X	There are continuous learning opportunities for me to improve my skills for my current and future jobs
Skills	M	I fully apply my skills and abilities in my work
Continuous improvement	Y_1	People here are open to trying new and different ways of addressing our business challenges
	Y_2	We continually work to ensure our processes are as efficient as possible
	Y_3	In my organizational unit, we do an excellent job anticipating new products, solutions, and services that our internal and external customers will value

Notes Adapted from from an employee survey 2015 of a knowledge-intensive company.

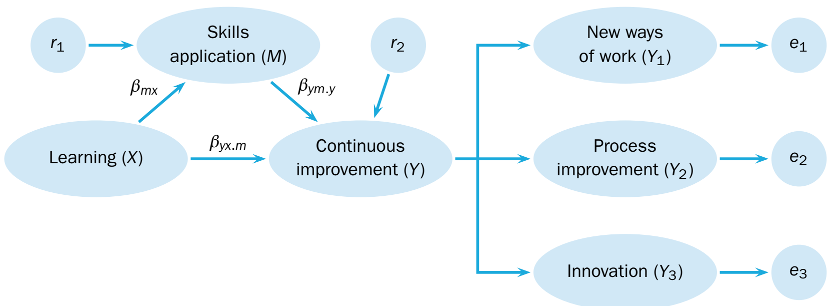

Figure 2 Pathway of a Mediation Process in the Partial Mediation Model for Learning

lenges within daily work; by improving processes and by working on innovations in products and services.

Accordingly, the research model to test the defined hypotheses is designed in Figure 2 in alignment on the methodology described by Byrne (2001) and Hayes (2018).

Figure 2 shows a path diagram for the relationships between the three variables: learning (x), skills application (m), and continuous improvement (y). The variables that are impacted by other variables, skills application and continuous improvement, are endogenous. The variable learning that impacts skills application and continuous improvement without being affected by them is an exogenous variable. The variables learning and skills applications are assumed to be observed variables, and the variable continuous improvement is a latent variable represented through 3 indicators.

The variables learning and skills application are measured with a single item. Behavioural constructs with one single-item can be successfully included in SEM when the indicator possesses a high degree of reliability

Table 2 Test for Normality

Variable	Skew	CR	Kurtosis	CR
Learning	1.902	47.064	3.404	42.108
Skills	0.652	16.140	–0.682	–8.435
Innovation	0.719	17.779	–0.186	–2.301
Process improvement	0.777	19.222	–0.510	–6.312
New ways of work	0.951	23.523	0.117	1.449
Multivariate			11.211	40.606

and validity (Petrescu, 2013). The criteria to justify the use of single-item measures were assessed based on the 'Criteria for Assessing the Potential Use of Single-Item Measures' (Fuchs & Diamantopoulos, 2009). For the variables learning and skills application, the justification criteria are concreteness of construct, diverse sample population, high semantic redundancy, and problematic to monitor changes.

βmx is the coefficient for X for predicting M, and $\beta ym.x$ and $\beta yx.m$ are the coefficients predicting Y from both M and X, respectively. $\beta yx.m$ is the direct effect of X. The direct effect, $\beta yx.m$, is the pathway from the exogenous variable to the outcome while controlling for the mediator. The product $\beta mx \times \beta ym$ quantifies the indirect effect of x on y through m. The indirect effect describes the pathway from the exogenous variable to the outcome through the mediator. The total effect is the sum of the direct and indirect effects of the exogenous variable on the outcome, $\beta yx.m + \beta mx$*?ym. $e1$, $e2$, and $e3$ are measurement errors associated with observed variables. $r1$ and $r2$ are the residual terms representing errors in the prediction of endogenous factors from exogenous factors.

The mediation analysis with structural equation modelling using bootstrap methods was executed in SPSS Amos 25.0.0 to test the derived hypothesis. The quality of the sample data set and descriptive statistics analysis were performed in SPSS Statistics 25.

Results

Due to the low percentage of missing data in the selected data set, the listwise deletion of missing values was performed. Fifty-seven cases (1,5%) were deleted, and 3,673 cases left for the analysis. The conclusion of data reliability was made based on the Cronbach alpha coefficient of 0.74 (Peterson, 1994). The results of the normality test for the sample of 3,673 cases are presented in Table 2.

The multivariate kurtosis value of 11.211 is Mardia's coefficient. Critical ratio (CR) values of 40.606 > 1.96 mean there is significant non-normality. This result is unsurprising because, strictly speaking, the data collected using rating scales violates the assumptions of normal distribution. The

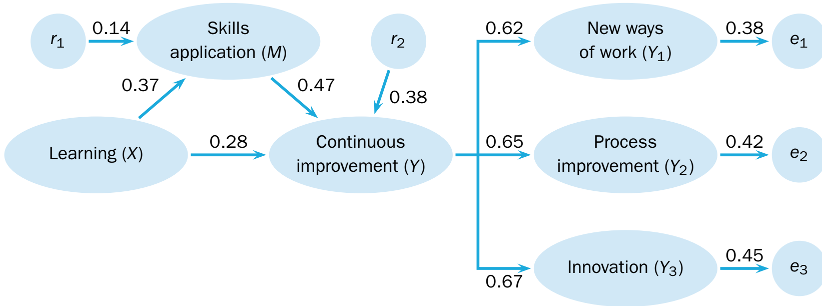

Figure 3 Pathway of a Mediation Process in the Partial Mediation Model of Learning (n = 3.673, $p < 0.001$)

bootstrap procedure within the SEM framework was applied to handle the multivariate nonnormal data as recommended by West, Finch, and Curran (1995). The bootstrap was executed on 5,000 samples using the maximum likelihood (ML) estimator and 95% bias-corrected confidence intervals for each of the bootstrap estimates.

The goodness-of-fit test statistics of the model achieved the required quality level. The fit index root mean square error of approximation (RMSEA) of 0.034 indicated a close fit of the model with the degrees of freedom. Regarding the quality of model matching, the value of the goodness of fit index (GFI) indicated that the model structure represents 99.8% of all empirical variances and covariances. Also, the adjusted goodness of fit index (AGFI) with a value of 0.992 confirms the imputed model structure. As reflected by the comparative fit index (CFI) = 0.995, the normed fit index (NFI) = 0.994, the relative fit index (RFI) = 0.985, the incremental index of fit (IFI) = 0.995, and the Tucker-Lewis index (TLI) = 0.988 make the model extremely well-fitting. In addition, the root mean square residual (RMR) value of 0.014 shows that only a variance fraction of 1.4% could not be explained. ML-estimated likelihood ratio χ^2 value of 20.6 with 4 degrees of freedom and ($p < 0.001$) will be not used as an indicator of goodness of fit between the model and the data, as χ^2 is highly sensitive to sample size (Byrne, 2001, pp. 79–88).

Figure 3 shows the model with standardized estimates of path coefficients and factor loading for the latent construct to address the research question by exploring the direct and indirect pathways by which learning influenced continuous improvement within an organization.

All estimated paths for the direct and indirect effects were statistically significant at level $p < 0.001$. The exogenous variable learning has a significant influence on mediator variable skills application. It also has a significant influence on endogenous latent construct continuous improvement

Table 3 Bootstrap ML Estimates

Paths	SE	SE-SE	Mean	Bias	SE-Bias	CR
Skills ← Learning	0.017	0.000	0.371	0.000	0.000	21.80
CI ← Learning	0.022	0.000	0.278	0.000	0.000	12.64
CI ← Skills	0.020	0.000	0.456	0.000	0.000	22.80
Innovation ← CI	0.016	0.000	0.673	0.000	0.000	42.06
Process improvement ← CI	0.016	0.000	0.650	0.000	0.000	40.63
New ways ← CI	0.017	0.000	0.619	0.000	0.000	36.41

Table 4 Bootstrap Confidence Intervals

Paths	Estimate	Lower	Upper	*p*
Skills ← Learning	0.371	0.337	0.403	0.000
CI ← Learning	0.277	0.235	0.320	0.000
CI ← Skills	0.456	0.416	0.495	0.000
Innovation ← CI	0.673	0.640	0.705	0.000
Process improvement ← CI	0.650	0.617	0.682	0.000
New ways ← CI	0.619	0.586	0.652	0.000

in the presence of mediator variable skills application. Therefore, skills application mediates the path between learning and continuous improvement. The results of the testing model by using the bootstrap method are presented in tables 3 and 4.

The standard errors determined based on bootstrapping are in the column 'SE.' There are no general limits for standard errors. The approximate standard error of bootstrap standard error itself ('SE-SE') is 0.000. In the column 'Mean' there is the mean parameter estimate computed across 5,000 bootstrap samples. Bias values of 0.000 suggest no discrepancy between the results of the bootstrap analysis and the original normal theory-based analysis. 'SE-Bias' is the approximate standard errors of the bias estimate with values of 0.000. By using the bootstrap Mean and SE columns, the critical ratio values based on the bootstrap results were calculated, additionally. They all are statistically significant at $p < 0.001$. The 95% bias-corrected confidence intervals for the standardized regression weight parameter estimates are shown together with the associated *P* values in table 5. The bias-corrected confidence interval does not include zero. Therefore, the hypothesis that the parameters are equal to zero is rejected at a significance level of less than 0.001 (Byrne, 2001).

The direct effect of learning on continuous improvement, $\beta yx.m = 0.28$. The indirect effect, $\beta mx*?ym = 0.37 \times 0.46 = 0.17$. An employee who differs by one unit in their learning is estimated to differ by 0.17 units in their participation in continuous improvement as a result of the effect of learning on skills application, which, in turn, affects continuous improvement. The total effect of learning on continuous improvement effect reveals how much two employees who differ by one unit on learning are estimated to differ in participation in continuous improvement: $\beta yx.m + \beta mx \times \beta ym = 0.28 + 0.17 = 0.45$. All effects statistically significant, as revealed by a 95% bootstrap upper and lower level CI, are entirely above zero. Bootstrapping analysis revealed that skills application mediated the relationship between learning and continuous improvement. The total effect is stronger than the direct effect, but the direct effect is stronger than the indirect effect. The squared multiple correlations for skills application and continuous improvement are 0.14 and 0.38, respectively. That means that 14% of the variance of skills application and 38% of the variance of continuous improvement is explained by learning. In summary, all four hypotheses cannot be rejected.

Discussion

Understanding the relationship between employees' learning and skills application, and continuous improvement practice within a company was the focus of this study. The structural, partial mediation model was analyzed with an ML estimator using 5,000 bootstrap samples. It was confirmed as well-fitted to the data. In the bootstrap approach, the effects of exogenous variable learning toward endogenous variable skills application and endogenous latent construct continuous improvement have been confirmed as statistically significant at a level less than 0.001. Thus, a mediation effect of skills application in the relationship between learning and continuous improvement was established, and it can account for 0.17 of the total effect. Despite the statistical significance of the effect, it is small. The direct effect of learning is more influential than the indirect effect. In summary, the total effect of 0.45 is the strongest. All four hypotheses were supported by empirical analysis. However, the predictive power of the skills application variable with 14% is weak. The construct continuous improvement with 38% can be considered specified as well. It is an indication for further research that, besides learning and skills application, other factors impact continuous improvement. In addition, skills application may also be specified as a latent construct. The specified model is a simple one and may be extended by further variables such as knowledge, leadership, job satisfaction. A second limitation of the study is non-random sampling. Thus, future research should include data from more than one company. However, the strength of the study is the utilization of a large sample, which included answers from employees from various countries.

Overall, the study provides empirical evidence on the mediation effect of skills application in the relationship between learning and continuous improvement using data from an operational unit of a knowledge-intensive company. It also gives an overview of the available theoretical basis on learning, skills application, and continuous improvement and summarizes what has been empirically proven on learning effects so far.

The results are relevant for operational companies in increasing employee participation in continuous improvement, setting up the right learning environment, and encourage skills application. The results showed that training should not be considered as an independent event: it needs to be connected to skills application. Both, efficient learning environment and the application of skills, are crucial to enjoying continuous improvement within an organization.

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Construction-Related Data Management: Classification and Description of Data from Different Perspectives

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The productivity improvement of the construction sector has fallen behind other industries. One potential factor is the on-site nature of the work that may not allow for as industrial way of operations as off-site construction. Also, the division into non-optimised chain of domains of architecture, engineering, construction and facilities management may play a role. The construction objects may not be considered as products that would necessitate careful consideration of the product structure, both commercially and technically to optimise the use of platforms, assemblies, components, and materials while offering what customers desire. Furthermore, the life-cycle of building objects and the varying needs during design, construction and the use-phase are not acknowledged effectively. Addressing the life-cycle of building objects necessitates taking command of the relevant data and understanding the bigger picture. Currently the data are managed in an un-organised manner. This study aims to form the pre-requisites for managing construction object-related data. The study is realised as a combination of a literature review and analysing constructors' offerings, requirements plans, Ministry reports, and building control documentations. A rather detailed example of construction object related data management is presented to discuss master data, and business process related data in the context of business processes and enterprise applications, and different Bills-of-Materials (BOM) configurations to demonstrate the necessary considerations. The example also acknowledges the product structure, necessary parameters, and stakeholders. New contribution is provided by presenting valuable insights with a broader scope for setting up effective data management in the construction sector.

Keywords: data management, master data, business data, construction industry, BOM configurations, product structure, business processes, enterprise applications, productization, product management

Introduction

The productivity of the construction industry is widely recognised as poor with negligent improvement (Fulford & Standing, 2014). The industry has, however, shown minor steady development like many other industries, but there is no match to the development rate of the best industries (Pekuri, Haapasalo, & Herrala, 2011). The on-site nature of the construction industry is one potential source of inefficiency as the construction activities take place at the site of construction (Eastman & Sacks, 2008). On-site activities are likely not possible to optimise industrially the same way as off-site construction and prefabrication. As a result, the cost of construction increases, and the prices of construction objects remain high. Industrialisation of construction and the increase of off-site activities might allow construction industry to act more like production industry and incorporate the latest product and process technologies and utilise automation to increase productivity (Linner & Bock, 2012).

The product structure concept is not widely utilised in the construction industry to provide a manageable logic for the construction offering (Harkonen, Tolonen, & Haapsalo, 2018). One example of this is apparent in industrialised construction where construction objects are produced in a factory to be installed at the construction site. The factory production takes place based on drawings or an illustration without exact details on materials to be used. This allows to produce as the employees see the best and may cause variation in quality based on differences in employee competence profiles. The concept of the Bills-of-Materials (BOM) is widely used in industrial sectors other than construction, and the product structure is central to enterprise applications such as ERP and PDM/PLM (Boton, Rivest, Forgues, & Jupp, 2016). Both concepts, product structure and BOM can be beneficial for the construction industry to convey information. Product structure is needed to provide an organised hierarchy of technical objects that are linked via 'part-of' relationships (Pinquié, Rivest, Segonds, & Véron, 2015), and BOM to list the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts, and the quantities of each needed to produce the object. Hence, product structure can have a role in organising the data that relate to construction objects (Boton et al. 2016)

The data management in the construction industry is challenged by the fragmentation into domains of architecture, engineering, construction and facilities management (Jiao et al. 2013). Data generated by one domain should be possible to share and be usable by others (Cerovsek, 2011). The project nature of construction industry also affects the data management (Bakis, Aouad, & Kagioglou, 2007). A construction project may consist of multiple phases such as tender, design, construction, and maintenance, and involve a variety of parties such as owners, architects, consultants, engineers, contractors, sub-contractors, and suppliers who all create data, whereas a project may utilise various IT systems (Shen et al., 2010). How well the diverse IT systems can manage and communicate electronic product and project data in such a fragmented environment can be a challenge (Jiao et al., 2013).

The practical challenges involve the life-cycle of building objects, and the variety in needs during the life-cycle that are not typically acknowledged. The needs during the design, construction, and the use-phase all have their specific focus. Building information modelling (BIM) has the potential to provide tools for managing construction object-related data through the life-cycle (Jiao et al., 2013) by covering construction process-related information in a digital format (Cerovsek, 2011).

The structuring that BIM is lacking would, however, be needed to improve the feasibility, design, construction and operational processes (Holzer, 2014). Thinking of productivity, the individual perspectives may not contribute towards the overall productivity. The architect may not aim to optimise the used components or number of different components to benefit construction, ignoring that some components are more cost-effective to use during construction and sourcing a smaller variety improves productivity. Similarly, the customers' perspective is important in terms of requirements, what the customer really wants and what are the boundary conditions for realisation. Also, the owner's or the maintenance company's perspective involving questions over the components the building object constitutes is important. The data and documentation are either missing or exist in a non-user-friendly format, which prevents knowing which components or materials have been used, and who has provided the materials. Also, should something break during the use-phase, a typical situation involves a maintenance person analysing locally which tap, or which building material needs replacing, instead of just checking the use-phase related data. The more complex the product, the more important it becomes to manage the various structures that allow the handling of the data generated along the life-cycle (Hameri & Nitter, 2002).

The construction industry is behind other industrial sectors in data management. The data are not managed in an organised manner. Fragmented documentations do exist, and they are managed to a varying degree. The data are not used as an asset to improve productivity and a data model is missing completely. This applies to large actors in the construction sector, not only the smaller ones. The initial awakening has taken place in the form of BIM efforts, but the ability to manage the whole is missing. The lack of adequate data management is weakening the true industrialisation of the construction sector.

This study aims to form prerequisites for data management and creating a data model for the construction industry by analysing construction object-related data. The above discussion can be condensed into the following research question:

How should construction object-related data be classified and described?

It is attempted to answer the research question by the means of an extensive literature review and by providing an example of construction object-related data management to discuss master data, and business process-related data in the context of business processes and enterprise applications, and different BOM configurations.

Literature Review

Product Data Management

Product structure has an essential role in organising data (Boton et al., 2016). Product structure is a hierarchy of a product into a structure to describe the decomposition of a product of any nature, physical, service, software, or their combination (Tolonen, Harkonen, & Haapsalo, 2014; Harkonen et al., 2017, 2018). The decomposition may vary depending on the use of the structure (Svensson & Malmqvist, 2002). The structure also has a role in managing bills-of-materials and various product configurations, providing functionalities for versioning, and linking parts (Eynard, Gallet, Nowak, & & Roucoules, 2004). A product data management (PDM) system is an enterprise application that can be used to manage the product structure (CIMdata, 2001), typically the technical side. The significance of the commercial structure is not widely understood in companies. Standards such as STEP (Standard for the Exchange of Product Data Model) also take a position on product data, enterprise applications and the product structure (Pratt, 2001). Different disciplines, such as design, manufacturing, purchasing, order management, spare parts, and service have varying needs for the decomposition of product structure and the functionality of the enterprise applications, hence they tend to work in different systems (Svensson & Malmqvist, 2002). Bill-of-Material (BOM) is the most common product structure that identifies echelon relations and reflects product assembly, often used in manufacturing related activities (Wu, Chien, Huang, & Huang, 2010), the technical composition. BOM structure is the structure often used in PDM systems with added metadata. The master structure can reside in PDM/PLM (Product Life-Cycle Management), or in ERP (Enterprise Resource Planning) and is transferred to other enterprise applications (Hannila, Tolonen, Harkonen, & Haapasalo, in press; Svensson & Malmqvist, 2002). The set of enterprise applications, their integrations and data transfer mechanisms may vary among companies.

The commercial composition is often not systematically linked to the enterprise applications in companies, even though the commercial side links to the customer focus, sales, marketing, and product management (Tolonen et al., 2014). The commercial structure also supports sales offers, contracts, orders, deliveries and invoicing (Tolonen, Harkonen, Haapsalo, & Hannila, 2018). The commercial product or service structure hierarchy can consist, for example, of product families, product configurations and sales items (Harkonen et al., 2017, 2018; Tolonen et al. 2014, 2018). The commercial structure is also possible to form amongst several companies to cooperate commercially (Mustonen, Tolonen, Harkonen, & Haapasalo, 2019). There are no differences in the logic of a commercial portfolio of products or services (Harkonen et al., 2018; Tolonen et al., 2018). The difference lies on the technical description. The product structure may also benefit company analytics by forming a frame for fact-based analysis (Lahtinen, Mustonen, & Harkonen, in press). The main aim of product structure and the related master data is to reach data consistency to enable fact-based analysis (Hannila, Koskinen, Harkonen, & Haapasalo, in press). For example, product profitability is possible to analyse in real time by comparing sales and cost information with the support of enterprise applications, data and product structure (Hannila, Tolonen, et al., in press). This, however necessitates the use of both commercial and technical structures.

The technical product structure is not static and necessitates data and product structure updates in the enterprise applications (CIMData, 1998; Hannila, Tolonen, et al., in press; Pinquié et al., 2015). Engineering Change Management (ECM) takes place through the life-cycle of a product and affects the product structure (Svensson & Malmqvist, 2002). Quality improvement or cost reduction activities may also affect the technical product structure. Verrollot, Kaikkonen, et al. (2017) illustrate the focus on product structure in case of activities of different nature, indicating that the focus should be sometimes limited to avoid extensive ripple effects.

The product structure concept relates to the concept of productization that deals with managing of products and services and the commercial and technical product portfolios (Harkonen et al., 2018; Mustonen, Seppänen, Tolonen, Harkonen, & Haapasalo, in press; Tolonen et al., 2018). Productization is a process of analysing a need, defining and combining suitable elements, into a product-like defined set of deliverables (Harkonen, Haapasalo, & Hanninen, 2015). Productization is also beneficial for managing a service offering (Harkonen et al., 2017). Due to the nature of services, productization allows actions by customers to be described along the same structure (Kuula, Haapasalo, & Tolonen, 2018). Hemple (2018) considered the market context in conjunction with service productization. The concept has also been demonstrated in the construction context (Harkonen et al., 2018). Unnecessary new technical descriptions of the same product can be avoided by forming the offering based on defined sales items to the extent that is possible. Logic must exist for introducing new sales items. The inefficiency that involves products and services can be addressed (Jaakkola, 2011; Valminen & Toivonen, 2012). The concepts of productization and product structure link to product portfolio management, and the life-cycle of products (Hannila, Tolonen, et al., in press; Tolonen et al. 2014; Tolonen, Shahmarichatghieh, Harkonen, & Haapasalo, 2015a; Tolonen, Harkonen, Verkasalo, & Haapasalo, 2015; Verrollot, Tolonen, Harkonen, & Haapasalo, 2017).

The product structure, productization, and enterprise applications are linked to company business processes. The role of traditional business processes should be to define how products are developed, sold, marketed, supplied, manufactured, ordered, delivered, invoiced, installed, maintained and repaired (Tolonen et al., 2014; Tolonen, Harkonen, et al., 2015; Hannila, Tolonen, et al., in press; Harkonen et al., 2017; Kuula et al., 2018). The product data, the information about the product, are linked to the integration of the functions and business processes of a company. The creation, development, handling, division and distribution of data connect the expertise of the organisation (Sääksvuori & Immonen, 2008).

Due to the volumes of data, companies utilise specific applications to manage product master data (Silvola, Jaaskelainen, Kropsu-Vehkapera, & Haapasalo 2011), which are then utilised over the life-cycle of the product (Stark, 2011; Silvola, Tolonen, Harkonen, Haapasalo, & Männistö, 2019; Hannila, Tolonen, et al., in press). In fact, Aiken and Billings (2013) view the value of data as that of a strategic company asset. Master data are defined as cleansed, standardised, and enterprise-widely integrated critical business information that relate to companies' transactions and analytical operations (Das & Mishra, 2011). Master data connect enterprise applications and business processes (Das & Mishra, 2011). Silvola et al. (2011) have linked the data, processes and IT applications and emphasised the importance of master data quality to the level of human DNA. Product master data are created during the design process, and then released for use by other company functions and business processes (Silvola et al., 2019). Product-related business data, on the other hand, relate to the business processes and includes product-related marketing and sales data, supply chain data, and service and care data. These data are utilised in the business processes and support the business transactions (Silvola, 2018).

Figure 1 synthesises the literature review and links construction object related master data, business data, business processes, product structure, and enterprise applications. Productization and product structure are prerequisites for effective construction object-related data management and provide a necessary structure to reach data consistency. Product structure is ideally stored in the same enterprise application as master data, at least for the technical part. The commercial part can be stored separately but

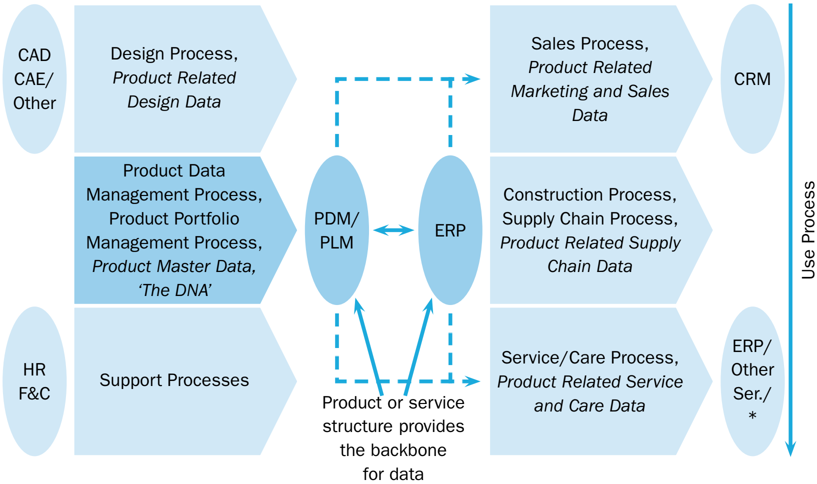


Figure 1 Literature Synthesis, Construction Object Related Master Data, Business Data, Business Processes, Product Structure, and Enterprise Applications (light – business data (reside in enterprise applications), dark – master data (reside in PDM/PLM system; ERP or BIM 2.0 if no PDM/PLM?), dashed arrows – master data are copied from the application they reside to other enterprise applications, * maintenance/care application)

must be linked to the technical structure. Enterprise applications relate to the business processes. The set of applications may differ from the presented but should have similar role and functions. If a company has a PDM/PLM system, then this is a natural location for master data. Master data are then copied to other enterprise applications. ERP may adopt the role if necessary, or the next generation of BIM, BIM 2.0 should there be prerequisites in terms of structure and function. Master data are the 'glue' that holds things together. Construction-related standards are acknowledged as a default.

Research Process

The study is realised as a combination of a literature review on relevant topics, analysing requirements for construction plans and reports based on decrees set by the Finnish Ministry of the Environment and the documentations by the building control of the biggest cities in Finland Helsinki, Vantaa, Espoo, Turku, Tampere, and Oulu). The requirements for construction plans and reports were analysed to ensure that all the mandatory design requirements are acknowledged. Otherwise, the discussed concepts are generic and applicable also elsewhere. In addition, the offering by various constructors are analysed. The purpose of analysing the offering by constructors was to analyse real construction objects in terms of how they are structured, and to demonstrate the discussed concept. A hypothetical example of construction object-related data management is created to discuss master data, and business process related data in the context of business processes and enterprise applications. Different BOM configurations are discussed in conjunction with the example. Product-related ownerships, stakeholders and relevant requirements and parameters are linked to the discussion to provide real context for the example. The construction object-related data management is linked to productization and product structure. The construction object-related data management is modelled by using real boundary conditions to enable true applicability.

The literature review aims to provide relevant understanding over the importance of construction object-related data management as an enabler for industrialisation of construction industry and utilisation of enterprise applications. The basic requirements for construction object-related data management are attempted to synthesise through discussing productization and products structure in the business process context and providing an example of linking the enterprise applications to the context. The role of master data and the business process-related data are attempted to clarify for the construction industry context. The industry-related standards and legal framework are analysed to a necessary degree. The literature review is realised by conducting key-word searches and analysing content that is seen as relevant.

The presented example is considered to the extent possible by publicly available material. The real offering by various constructors are utilised. The information on constructors' offering have been obtained from publicly available materials. The construction companies whose offering have been analysed include Honka, Kontio, and Mammuttihirsi. The companies were selected by the means of convenience sampling in search to find easily understandable construction offerings as a way to create a realistic example to demonstrate the discussed concept. In convenience sampling, the researchers choose a sample from a population (Etikan, Musa, & Alkassim, 2016). Cases are selected based on their availability for the study (Henry, 1990). This type of sampling has limitations, which include non-random selection of research objects, potentially making researchers subjective and biased (Etikan et al., 2016). Generalisation of results may not be fully allowed due to the likely bias (Henry, 1990). Adequate availability of materials was also a criterion, further promoting convenience sampling. The construction object-related data management is considered in the context of construction setting. The presented data management concept has not been reviewed with construction professionals. The data management of different construction actors is possible to analyse against the example presented in this study.

Results

Construction companies do not seem to manage their data adequately even though many actors have taken some efforts towards digitalisation. There has been awareness over the lack of productivity improvement in this industry sector for decades, but no one has had the magic wand to rectify the situation. Digitalisation and industrialisation of construction are possibilities that may support improving the productivity. Managing construction object related data so that they have true significance for the operations, and to create meaningful information and value, are necessary to be considered alongside integrating the business processes and data processes. Offering a centric approach is needed with the support of productization and product structure to provide the basis for effective data management and analysis. The productized construction offering needs to be linked with the relevant business processes and enterprise applications. This whole needs to be considered alongside construction object-related master data and business data. All these together may provide essential prerequisites towards creating a data model for the construction industry, and the true digitalisation of the industry in a meaningful manner.

As a major result of this study, an example of construction object-related data management is created to discuss basic principles of master data, and business process-related data in the context of productization, product structure, business processes and enterprise applications. The life-cycle and the varying needs in different stages are attempted to acknowledge by discussing different BOM configurations alongside the example. The necessary construction offering-related ownerships, stakeholders and relevant requirements and parameters are linked to the discussion to enable true applicability.

Figure 2 illustrates examples of construction object-related master data and business data. Construction object-related master data includes the data that are created during the design phase. These data are then released to be used by other company functions and business processes. These data are validated at different phases of the design process and related meetings to ensure they meet the needs of the business processes. The nature of master data necessitates uncompromised data quality. Master data must be understandable by the layman. One possibility to store and manage master data is to utilise a PDM/PLM system, but other solutions may also exist. The focus ought to be on avoiding a situation where master data are not systematically tracked and controlled. Construction offering-related documentation, versions, processes and work-flows, product structure and components must be managed effectively to cope with the complexity. Nevertheless, the project nature of construction business

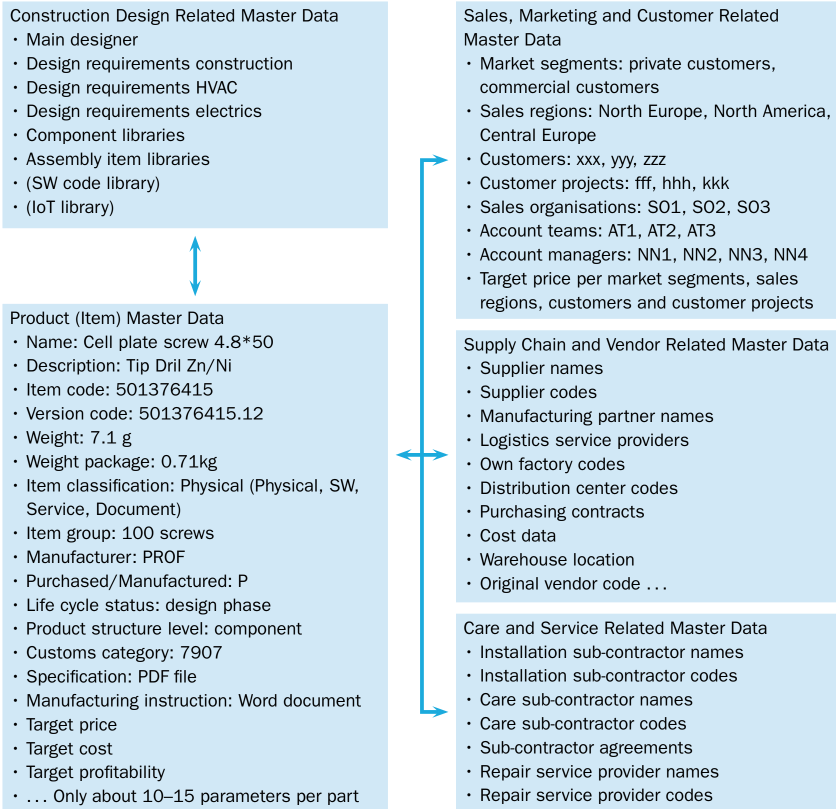


Figure 2 Examples of Construction Object-Related Master Data and Business Data

might also be necessary to acknowledge, should a PDM/PLM system be utilised.

Construction design-related master data must include information on the designers and different designs. Designs requirements at least for construction, heating, ventilation, and air conditioning (HVAC), and electrics are necessary. Construction design master data must also contain component libraries, and assembly item libraries. Should the construction design involve software (SW), or Internet of Things solutions in the form of sensors and Internet connectivity, then the corresponding libraries should be part of the construction design master data.

As local law and building control may set requirements for construction, the necessary compatibility may need to be considered alongside the data. Variety of plans may be required, such as the construction design and site plan. There may also be a variety of additional plans, such as floor plan, cutting drawings, and facade drawings. In addition, special plans such as structural drawings and structural calculations, including loads, strength of bearing structures, measurements, and the insulation of thermal moisture, water pressure, noise and vibration insulation may be required. Hence, the construction object-related data must be considered accordingly.

Product (Item) master data should contain 10–15 parameters for each part necessary for the construction object. The presented example involves a screw that is needed to attach a cell plate that forms light roofing. The necessity to manage master data may help in guiding construction design towards utilising as many common components as possible in construction design, and further improve productivity. Or otherwise said, design construction objects by only utilising a certain set of components.

The business process related master data are also necessary to be defined, including sales, marketing- and customer-related operations, supply chain, and vendor, and care- and services-related master data. The necessary related parameters must be carefully considered. The related considerations also include the enterprise applications that the construction company must set a meaningful master/slave logic for the applications, that is where the master data reside. The data are then copied to the other applications. In general, master data are usually non-transactional information about customers, products, employees, materials, suppliers, and vendors.

Construction object-related business data mean in practice product data with business process-related additional data that are needed to perform the process-specific transactions. The business data can be stored in the specific applications that link to the corresponding business processes. The nature of business data is different than that of master data, as business data can change and are not as critical in terms of minor issues in related data quality.

Finding 1 *Master data and business data are necessary to be defined and considered to support construction object-related data management. This may also support considering the roles of business processes, enterprise applications and the data.*

Figure 3 illustrates construction-related business processes and data in the context of BOM configurations at different life-cycle stages. Bills of materials (BOM) relate to the technical productization of the construction object, the technical side of the product structure. Different BOM configurations are needed to consider and effectively manage the life-cycle of a construction object. The needs at different life-cycle stages vary, hence the differences must be acknowledged by the means of product structure and data. The technical product structure can be managed in a PDM/PLM system or in ERP. Where the commercial product structure should be managed is yet another question. Regardless of where the technical side is man-

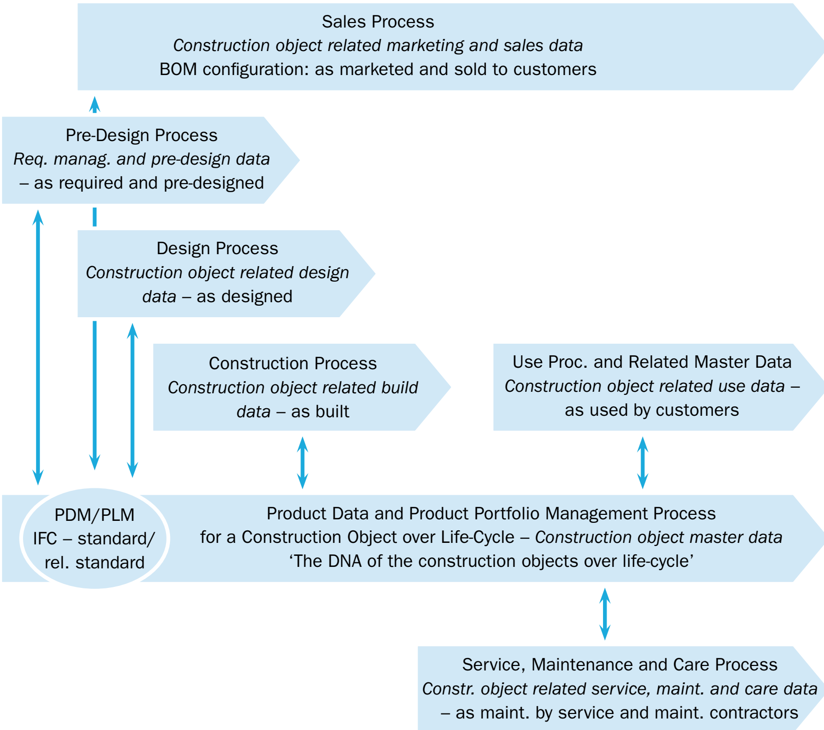


Figure 3 Construction-Related Business Processes and Data in the Context of BOM Configurations

aged, the configurations must be reconcilable to support effective BOM management. This supports identifying impacts of changes from different perspectives, technical, documentary, or other, and further track histories and causes. BOM configurations also enable comparing construction objects in different life-cycle phases. *As designed* configuration, for example, may support developing material plans in ERP. In general, information can be obtained along the same structure. The BOM configurations further support effective configuration management.

A business process for analysing and deciding on company's products now and in the future, the construction product portfolio management should deal with the DNA of the construction objects over the life-cycle. The enterprise application that stores the construction object master data links logically to this business process. The relevant construction industry standards should be considered alongside the data management. The role of the other business processes would then be to define how construction objects are designed, sold, constructed, supplied, manufactured, ordered, delivered, invoiced, installed, maintained, and repaired.

The most obvious BOM configurations relate to the sales process, that is, how the objects are sold and marketed to customers. The data that link to the sales process involve the marketing and sales data. To take the specific nature of the construction industry into account, a pre-design process can be necessary to link to *as required and pre-designed* BOM configuration. The data involve the requirements and pre-design data. Design process relates to the actual design of the construction object, *as designed* BOM configuration, and the design data. The design process and the pre-design process can be partially simultaneous. The construction process relates to the actual construction, *as built* BOM configurations and the build data. As construction objects are used, the use process should be considered. The use process relates to the BOM configuration *as used* by customers, and the use data. Service and maintenance processes relate to the *as maintained* BOM configuration and the related service, maintenance and care data. As the nature of certain processes is such that the same actor does not always take care of these processes, the needed applications should be considered carefully. For example, should there be a separate maintenance company, the original constructor should provide the necessary BOM configuration.

Considering construction object-related business processes and data in this type of context allow linking to relevant stakeholders and relevant standards. It should be understood how a construction object can be a house, building, bridge, road, city, or other construction related object.

Finding 2 *Considering construction-related business processes, data, and BOM configurations may prove beneficial for promoting meaningful data management and digitalisation.*

Figure 4 illustrates how a construction object can be linked to commercial productization and the product structure. An example of a log house is utilised to demonstrate master data in conjunction with construction product configuration and a sales item. It should be understood how a product configuration is constituted of sales items, both of which can be given a price as the company knows the corresponding technical composition and the related costs. It is the commercial product portfolio that is typically visible to the customer. The company can use different logics for productizing the offering along a logical product structure. The master data can be stored in a PDM/PLM system, as well as the technical side of the product structure can be managed through a PDM/PLM system, or ERP. The main open question remains where companies should manage the commercial product structure as reluctance may exist in involving the commercial side in an individual application.

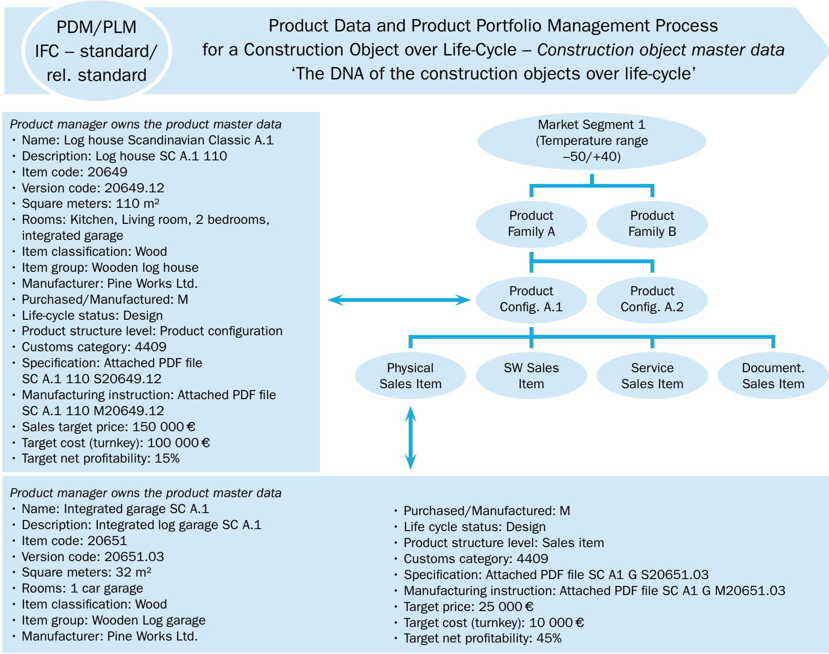
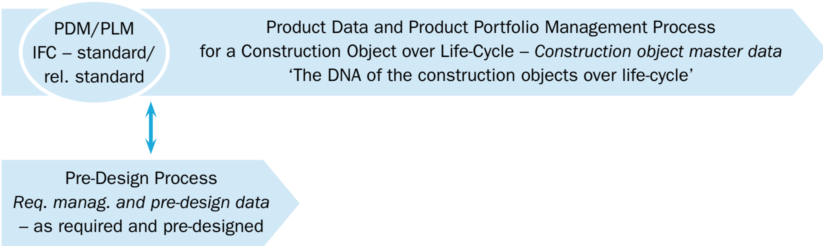


Figure 4 Construction Object Related Master Data and Commercial Productization

Finding 3 *Construction object-related master data can be linked to commercial productization in a meaningful way.*

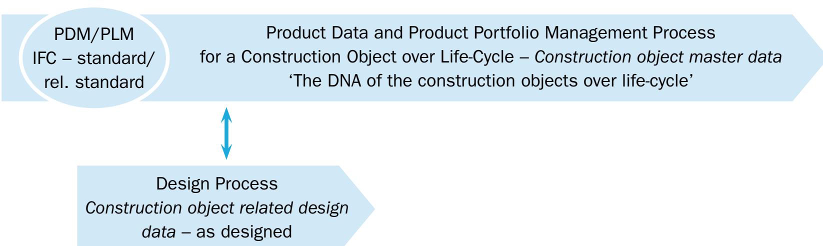
Figure 5 illustrates the linkage of a pre-design process, requirements management, and pre-design data, and the *as required and pre-designed* BOM configuration. The data created during the design process are fed to the application that is selected to manage the data. The application can be a PDM/PLM system, one that can acknowledge the industry specifics. Noteworthy is that PDM/PLM systems are not yet very common within the construction industry, not even with large actors, as data are currently insufficiently considered. If design systems are utilised, they should be linked to the pre-design process. The log house specific example illustrates important requirements, potential related stakeholders and which requirements are stored in the system that is used to manage data.

Similarly, Figure 6 illustrates the construction object-related design data and the *as designed* BOM configuration in the design process context by using the same log house example. The design process can and should utilise the previous data with the support of product structure and feed the used data management system as the source of master data. If design systems are utilised, they should be linked to the design process. The de-



Requirements	Stakeholder	Product master data in PDM
Temperature range: –50°C/+40°C	End-customer, Sales manager	x
Square meters: 110 m²	End-customer, Sales manager	x
Rooms: Kitchen, Living room, 2 bedrooms, integrated garage	End-customer, Sales manager	x
Material type: Log Wood	End-customer, Sales Manager	x
Life-cycle status: requirements management and pre-design	Product manager	x
Product structure level: product configuration	Product manager	x
Original customer requirement specification: attached PDF file SC A.1 110 C20649.12	Sales manager	
Country, area and community related specifications: Finland, rural area, Inari	End-customer, Sales manager	
Type of construction site: Lake side, Sandy soil	End-customer, Sales manager	
Legal requirements:. . .	Municipality Inari, Sales manager	
Customer target price: 140000–160000 €	End-customer, Sales manager	
Sales target price: 150000 €	Sales manager, Product manager	x
Target cost: 100000 € (as pre-designed)	Sales manager, Product manager	x
Target net profitability: 21%	Sales manager, Product manager	x

Figure 5 Construction Object-Related Pre-Design Data and As Required and Pre-Designed BOM Configuration

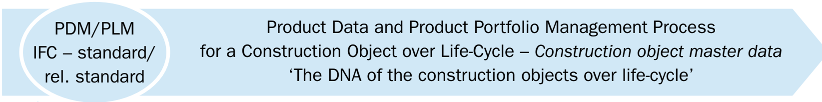


Requirements	Stakeholder	Product master data in PDM
Temperature range: –50°C/+40°C	Product manager, Designer	x
Square meters: 110 m²	Product manager, Architect, Designer, End customer	x
Rooms: Kitchen, Living room, 2 bedrooms, integrated garage	Product manager, Architect, Designer, End Customer	x
Material type: Log Wood	Product manager Architect, Designer	x
Life-cycle status: design	Product manager	x
Product structure level: product configuration	Product manager	x
Design specification: attached PDF file SC A.1 110 D20649.12	Designer	
Construction design for groundwork	Designer	
Heating, Water and Air design	HVAC designer (Heating, ventilation, and air conditioning)	
Sales target price: 150 000 €	Product manager, Sales manager	x
Target cost: 100 000 € → 110 000 € (as designed)	Product manager, designer	x
Target net profitability: 21% → 20%	Product manager	x

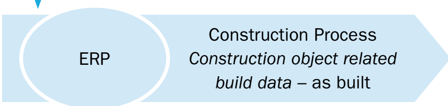
Figure 6 Construction Object-Related Design Data and As Designed BOM Configuration

sign parameters and potential stakeholders can be linked to the context.

Figure 7 illustrates the construction process, the related build data and the *as built* BOM configuration. Examples of related product master data parameters are provided together with stakeholder information. The rele-



Product master data parameters	Stakeholder
Square meters: 110m²	Product manager, Construction manager
Rooms: Kitchen, Living room, 2 bedrooms, integrated garage	Product manager, Construction manager
Material type: Log Wood	Product manager, Construction manager
Life-cycle status: Construction	Product manager
Product structure level: Product configuration	Product manager
Sales target price: 150 000 €	Product manager, Sales manager
Target cost: 110 000 € → 90 000 € (as constructed)	Product manager, Construction manager
Target net profitability: 20% → 36%	Product manager



Build parameters	Stakeholder
Building instructions and specification: attached PDF file SC A.1 110 B20649.12	Designer, Construction manager
Building instructions for groundwork	Designer, Construction manager, Ground work sub contractor
Building instructions for Heating, Water and Air	HVAC designer, Construction manager, HVAC-subcontractor

Figure 7 Construction Object-Related Build Data and As Built BOM Configuration

vant build parameters can be linked to the construction process, as well as can the relevant stakeholders. The context is the same log house example. As construction process operational by nature enterprise resource planning (ERP) is logical to be used in the context of the business process. It is possible that BOM master resides in ERP, or in a PDM/PLM system. All the activities should be guided by the product structure, so data can be logically linked to the structure to link the applications and business processes. If master data reside in PDM/PLM, then the master data are copied to ERP.

Figure 8 illustrates the sales process, the related marketing and sales data, and *as marketed and sold* BOM configuration. The context is the same log house example. Examples of related product master data parameters are provided together with stakeholder information. The relevant marketing and sales parameters are linked to the sales process, as well as the relevant stakeholders. Due to the nature of the sales process, a separate customer relationship management system may be necessary. The sales process should be linked to commercial productization and the commercial product portfolio to logically guide the sales process so that sales will include existing and possible/allowed configurations of construction objects.

Figure 9 links the construction object-related use process, related master data and the *as used* BOM configuration. Examples of related product master data parameters are provided together with stakeholder information. The living process related parameters and relevant stakeholders can be linked to the context of the same log house example. The company who constructed the log house will have the relevant master data in their data

PDM/PLM
IFC – standard/
rel. standard

Product Data and Product Portfolio Management Process
for a Construction Object over Life-Cycle – *Construction object master data*
'The DNA of the construction objects over life-cycle'

Product master data parameters	Stakeholder
Square meters: 110m²	Product manager, Construction manager
Rooms: Kitchen, Living room, 2 bedrooms, integrated garage	Product manager, Construction manager
Material type: Log Wood	Product manager, Construction manager
Life-cycle status: Maintain	Product manager
Product structure level: Product configuration	Product manager
Sales target price: 150 000 €	Product manager, Sales manager
Target cost: 110 000 € → 90 000 € (as constructed)	Product manager, Construction manager
Target net profitability: 20% → 36%	Product manager

ERP

Sales Process
Construction object related marketing and sales data
BOM configuration: as marketed and sold to customers

Marketing and sales parameters	Stakeholder
Name of the customer	Sales manager
Customer address	Sales manager
Actual customer price: 170 000 €	Sales manager
Rental price: 500 €/month	End-customer (owner), Sales manager
Marketing material for Sales partners	Sales manager, Sales partners

Figure 8 Construction Object + Related Marketing and Sales Data and As Marketed and Sold BOM Configuration

PDM/PLM
IFC – standard/
rel. standard

Product Data and Product Portfolio Management Process
for a Construction Object over Life-Cycle – *Construction object master data*
'The DNA of the construction objects over life-cycle'

Product master data parameters	Stakeholder
Square meters: 110m²	Product manager, Construction manager
Rooms: Kitchen, Living room, 2 bedrooms, integrated garage	Product manager, Construction manager
Material type: Log Wood	Product manager, Construction manager
Life-cycle status: Maintain	Product manager
Product structure level: Product configuration	Product manager
Sales target price: 150 000 €	Product manager, Sales manager
Target cost: 110 000 € → 90 000 € (as constructed)	Product manager, Construction manager
Target net profitability: 20% → 36%	Product manager

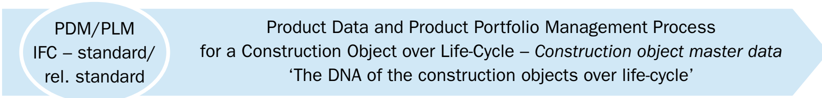
ERP

Use Process and Related Master Data
Construction object related use data –
as used by customers

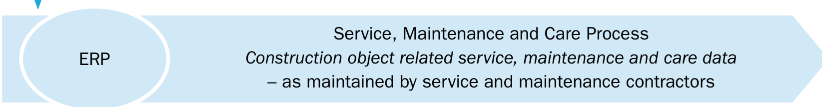
Living process related parameters	Stakeholder
Name of the owner	Estate manager, Owner
Address of the owner	Estate manager, Owner
Name of the end-customer	Estate manager, Owner, End-customer
Address of the end-customer	Estate manager, Owner, End-customer
Water consumption	Estate manager, Owner, End-customer
Heating consumption	Estate manager, Owner, End-customer
Rental price	Estate manager, Owner, End-customer

Figure 9 Construction Object Use Process and Related Master Data and As Used BOM Configuration

management system. Use process can be considered as operational so that should the construction company also manage the construction object during the use-phase, ERP is a logical in the context. Should the construc-



Product master data parameters	Stakeholder
Sales target price: 150 000 €	Product manager, Sales manager
Target cost: 90 000 € → 95 000 € (maintained)	Product manager, Construction manager
Target net profitability: 36% → 32%	Product manager
Life-cycle status: Maintain	Product manager
Type of water pump	Product manager, Estate manager, Care manager
Type of cooling fan	Product manager, Estate manager, Care manager
Type of floor	Product manager, Estate manager, Care manager



Service, maintenance and care process related parameters	Stakeholder
Name of water pump service and care sub-contractor	Estate manager, Care manager, Owner
Name of cooling fan service and care sub-contractor	Estate manager, Care manager, Owner

Figure 10 Construction Object Service, Care and Maintenance Process and Related Data and As Maintained BOM Configuration

tion company not be involved during the use-phase, a separate management company and their ERP could be linked into the context in terms of the *as used* BOM configuration to support activities during the use-phase. In case of a private customer, the necessary use-phase data can be provided in a suitable format and can contain information that would not exist without adequate data management.

Figure 10 illustrates construction object-related service, care and maintenance process, related data and links to the *as maintained* BOM configuration. Examples of related product master data parameters are provided together with stakeholder information. The service, care and maintenance process related parameters and relevant stakeholders can be linked to the context of the same log house example. Service, care and maintenance process can be considered operational so that the construction company should also manage the construction object during this phase, ERP is logical in the context. Should the construction company not be involved during the use-phase or be partially involved, a separate management company and their ERP could be linked into the context in terms of the as maintained BOM configuration to support activities during this phase. In case of a private customer, the necessary use maintenance-related data can be provided in a suitable format and can contain information that would not exist without adequate data management. This type of thinking may provide new opportunities and possibilities for efficiency improvement.

Finding 4 *Construction object-related data management may benefit greatly of considering master data, business processes, and BOM configura-*

tions together with related parameters and stakeholders together with linkages to necessary enterprise applications and productization.

Discussion

Construction object-related data management is a topic that is insufficiently addressed by construction companies. It appears that there is a need to better understand master data and business data, and their role to enable effective and meaningful data management in construction. This understanding may further support considering the roles of business processes, enterprise applications and data in construction to improve productivity and enable effective digitalisation.

Construction object-related master data are the data that are created during the design phase. These data are released to be used by other company functions and business processes. Master data are validated at different phases of design process to ensure they meet the needs of the business processes. The quality of master data should not be compromised. Construction object-related business data are product data with business process-related additional data that are needed to perform transactions.

The boundary conditions set by law and building control, as well as the specific nature of the construction industry, should be acknowledged alongside the data management to ensure the optimal meaningfulness of the activities. Productization of the offering, both commercially and technically, is a necessary pre-requisite to ensure a systematic product structure to support data management. The higher-level logic of data management is rarely discussed in the construction context. This logic should involve the construction offering and the related logic, the productization, the data, the business processes, relevant enterprise applications and their roles. The thinking can be taken a step further to acknowledge the BOM configurations and the relevant parameters and stakeholders. This may provide the necessary building blocks towards meaningful digitalisation of the construction industry together with many potential benefits.

Managing the portfolio of construction objects along the life-cycle, and the active analysis over profitability are along the potential benefits. Also, effective configurability and modularity are possible through productization, not to mention configuration management and value chain considerations. The construction objects can be effectively connected to the delivery process. Master data are the glue that holds the variety of considerations together. The true industrialisation of the construction industry and related gains in terms of economy of scale and productivity may become possible.

Finding 5 *Construction object-related data management could be an enabler for the productivity of construction industry.*

Scientific Implications

The scientific implications include highlighting the construction object in the data management context and providing a tangible example that considers master data and business data in the context of product structure, business processes, and enterprise applications. The findings are in line with previous studies by Pinquié et al. (2015), Tolonen et al. (2014), and Harkonen et al. (2017, 2018) in terms of product structure, but provide new discussions in the context of construction objects. This study is particularly in line with Boton et al. (2016) in product structure having a role in organising data. The results also concur with Eynard et al. (2004) in the structure having a role in managing BOMs and product configurations. A new contribution is, however, provided by emphasising the role of commercial product structure that is not commonly covered by the literature in the data context. This study is in line with Hannila, Tolonen, et al. (in press), Svensson and Malmqvist (2002), and Pinquié et al. (2015) in the product structure being transferred to other enterprise applications along updates. The findings also concur with CIMdata (2001) in that PDM/PLM can be used to manage the structure. The application is, however, not very common in the construction industry, as companies have not realised on how to utilise a system that integrates project management to better fit the nature of the business. This indication is a new contribution. ERP is indicated as an alternative. This study is in line with Svensson and Malmqvist (2002) with different needs for views in terms of product structure. A new contribution is provided to the discussion on different views and varying needs by presenting different BOM configurations in the construction context. The related productization discussion by Hemple (2018), Harkonen et al. (2015; 2017; 2018), Tolonen et al. (2018), and Kuula et al. (2018) also provided support by providing a practically relevant example in the construction setting. Master data Discussion by Stark (2011), Aiken and Billings (2013), and Das and Mishra (2011) is supported by presenting an example in the construction context. Authors that have attempted to paint a more comprehensive picture with their specific focus (Hannila, Tolonen, et al., in press; Hannila, Koskien, et al., in press; Silvola et al., 2011, 2019) are complemented by presenting a construction industry specific example. New contribution is, however, provided by indicating some industry specific issues and taking the discussion to parameter and stakeholder levels, while including the product structure in more detail.

The discussion on construction industry productivity by Fulford and Standing (2014), and Pekuri et al. (2011) is supported by indicating new avenues for improving the productivity by the means of better data management. The industrialisation of construction activities (Linner & Bock, 2012) is supported by providing true means for supporting data management. This may entail design actions by using a set of pre-defined components to benefit also other company activities aside data management, as well as the effective utilisation of product structure and BOM. The findings provide support for Jiao et al. (2013) and some food for thought for avoiding pitfalls of fragmentation into domains of architecture, engineering, construction and facilities management. New ideas are provided by highlighting the roles of product structure and data management. The findings support Cerovsek (2011) in emphasising the importance of possibilities of data being used by other domains. The challenge of the project nature (Bakis et al., 2007) provides solution-oriented support by indicating possibilities of the enterprise application selection.

Overall the new contribution includes linking data, business processes, enterprise applications, productization, product structure concept, necessary parameters, and stakeholders in construction data management context. New contribution is provided by discussing different BOM configurations and data management in the construction industry context. A new contribution might be provided to the construction specific life-cycle discussion. Discussion on business processes and enterprise applications in the data context is supported. Also, the digitalisation discussion in construction setting is supported by providing a meaningful set of building blocks to digitalise effectively.

Managerial Implications

The managerial implications of the study include providing a rather practical example of how construction object-related data management can be considered. The example includes an entity that covers aspects from the very practical level of what master data and business data are to providing a structure for managing data via product structure. The roles of business processes and enterprise applications are also linked to the entity. Different BOM configurations, related parameters and stakeholders are discussed in the context of business processes and product structure. Responsible managers in the construction sector can gain valuable insights with a broader scope for setting up their data management for future competitiveness. The discussed concepts are linked to other valuable concepts, such as product portfolio management, life-cycle management and company analytics that may prove beneficial for tomorrow's profitability and business success. Managers may benefit of the understanding that designing construction objects based on a pre-defined set of components can support avoiding unnecessary business complexity. In other words, one-of-a-kind-components may not always be necessary for standards construction objects, and it is possible to generate architectural value also in other ways.

Limitations and Future Studies

The limitations of this study include considering the data management of construction objects by utilising publicly available material, and not confirming the findings with construction professionals to obtain their feedback. A certain criterion of practicality was utilised. The rather detailed but simple example can, however, prove valuable for construction or any other professionals in related fields. Mandatory design requirements are checked in the context of Finland only, but otherwise the presented concepts are generic. Not including further details on related constructions standards may also be a limitation. Naturally, there are possibilities of organising data management in different ways, but there are no comprehensive descriptions available anywhere in the existing literature for construction objects. Future studies can address the limitations of this study, and include real-life examples in the construction setting, if any are available. The findings can be tested with a random sample of construction professionals to confirm the relevance of the findings. Also, the analytics possible via the product structure and master data may prove an interesting topic for future studies in the construction setting.

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Data Privacy Assessment: An Exemplary Case for Higher Education Institutions

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The European General Data Protection Regulation (GDPR), which became applicable in May 2018, obliges companies and thus Higher Education Institutions (HEIs) to (re)assess their data privacy procedures, in particular the processing of personal data. As the new law unfolds an extraterritorial scope, HEIs located outside the European Union (EU) also need to examine whether they are affected, and, if so, take the necessary measures. There is a lack of discussion and approaches in the current literature as to how HEIs can comply with the GDPR regulations. The aim of this study is therefore to analyse scientific publications in order to deliver two results: Firstly, consolidated relevant recommendations and requirements in the context of GDPR, and, secondly, an instrument to help HEIs to raise their GDPR awareness. The latter was built by applying design science guidelines and resulted on a whole of 44 controls that yield a total score. The resulting value can serve as an indicator of HEI's accordance with GDPR regulations. In addition, the compiled controls can be used as a management instrument to assess the measures taken and to continuously promote compliance with GDPR.

Keywords: assessment instrument, assessment tool, data privacy, European General Data Protection Regulation, higher education institutions

Introduction

The right to privacy in Europe is considered fundamental, as stated in Article 8 of the European Convention on Human Rights (European Court of Human Rights, 2018): 'Everyone has the right to respect for his private and family life, his home and his correspondence.'

The headlines of the recent news highlight the serious consequences faced by some companies after abuse of privacy was made public. One of the best-known case occurred in 2018, when Cambridge Analytica, a British political data analysis company, announced that they had mistakenly acquired data from tens of millions Facebook users without their consent and then used these data to try to influence political decision-making, namely the US presidential election (Wong, 2019). The data breach led to a loss of reputation along with a financial one represented by a drop in Facebook's stock price of 17.44 points (Segarra, 2018). To minimize occurrence of such incidents, the European Union (EU), on 27th of April 2016, approved the General Data Protection Regulation (GDPR), a law that unfolds extraterritorial scope and therefore affects organizations worldwide (The European Parliament and The Council of the EU, 2016). This newly created regulation has obliged all EU Member States to integrate the legal provisions into their own national law by 6 May 2018 (Albrecht, 2016).

Like other organizations, Higher Education Institutions (HEIs) rely heavily on the processing of personal data and are concerned with GDPR in case they reside in the Union or process data from people who are in the EU. This study focuses on HEIs in Switzerland – not part of the EU; yet these organizations are likely to process data of individuals residing in the EU, such as students, alumni or parents of students or alumni. Even though Switzerland has a long tradition in data privacy and is a highly internationalized country, more emphasis needs to be placed on the EU regulation. A recent survey by the Swiss ZHAW School of Management and Law reports that, although the majority of Swiss companies surveyed consider data protection as important or rather important, the GDPR is not sufficiently well known. In addition, only about a quarter of the companies expect to be affected by the EU regulation (Ebert & Widmer, 2018). This is contrary to the estimates of various stakeholders (e.g., lawyers, consultants), who assume that the majority of Swiss companies are concerned (Lurati, 2018; Müller, 2017). Turning to the specific case of HEIs in Switzerland, there has been a lack of specific studies regarding GDPR, thus this study aims to contribute to close the gap. As the Swiss data protection law is currently under review and is expected to converge on EU standards, some guidance for Swiss HEIs to support GDPR compliance will be a useful contribution to academia and practice. Additionally, since this study focuses on Switzerland as a non-EU country, the results of this research can also be applied to other non-EU countries.

The purpose of this work is to emphasize the importance of data privacy compliance for HEIs and to provide a prototypical assessment instrument for HEIs in Switzerland that could be utilized to analyse the institutions' readiness to follow GDPR. The assessment instrument allows the measurement of performance on GDPR, with tailored questions that are understandable to compliance specialists who can test the prototype and use it as a first and quick auditing tool.

We have worked out two research questions: (1) What are the GDPR's re-

Table 1 Literature Search Parameters Applied for This Research

Parameter	Value
Language of Publication	English
Subject Area	Legal, Business
Business Sector	Education, other (Data privacy/GDPR related)
Geographical Area	EU, Switzerland
Publication Period	Last 5 years, plus exceptions for classical publications
Literature Type	Books, scientific papers, refereed journals, practitioner papers

quirements for HEIs? This first question is relevant because our study sets a specific focus on Switzerland and the organizational type of HEIs as an exemplary unit of analysis. Even though GDPR is a regulation that applies to all industries, each sector is facing its particular challenges due to different types of data to be processed. (2) How could a GDPR assessment instrument look like to support Swiss HEIs' compliance with the law? This second question is relevant, as our study not only aims to investigate challenges, but also to achieve practical benefits. As the survey of ZHAW School of Management and Law (Ebert & Widmer, 2018) shows, Swiss companies – this includes HEIs – should be more concerned to comply with GDPR. Therefore, providing them with a well-adopted assessment instrument, could serve as a means to raise awareness.

To answer the research questions, the first methodological step was a literature review according to the guidelines of Saunders, Lewis, and Thornhill (2009). The chosen procedure relies on the definition of search parameters for obtaining relevant literature. As to the scope of this study, the selected parameter values are listed in Table 1.

As a second methodological approach, the Design Science Research (DSR) guidelines of Hevner & Chatterjee (2010) were applied. According to Hevner, Salvatore, Jinsoo, and Sudha (2004), DSR must lead to an artefact, which could be a construct, model, method or an instantiation and it aims to align technical and business aspects. This was considered suitable for our research, which aims to yield a GDRP assessment tool. A first version of the tool was derived using information gained from the existing knowledge base and from the HEIs' environment in Switzerland. The prototype was then improved on the basis of an evaluation obtained by a team of experts in the fields of governance, risk and compliance. In the future, a continuous improvement cycle should further sharpen the performance of the assessment instrument.

To develop the intended tool, the DSR approach is well-suited to align research processes with real-world problems and to integrate business with technical aspects. Figure 1 shows how the research framework of Hevner et

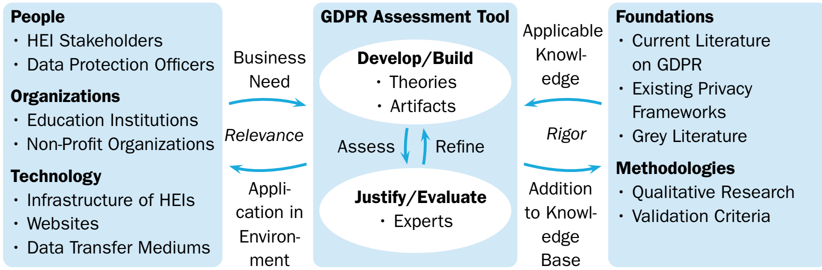


Figure 1 Research Framework of This Study (Adapted from Hevner et al., 2004)

al. (2004) was adapted. The knowledge base, represented with the systematic literature review, allowed to build and evaluate the intended 'GDPR Assessment Tool for HEIs' and constituted the rigor cycle. On the other hand, the environment, represented by HEIs in Switzerland and its surrounding, composed the relevance cycle, which the artefact drew its relevance from.

The remainder of our paper is structured as follows. First some backgrounds about GDPR are described, followed by an elaboration of requirements the GDPR places on the universities. Afterwards, an analysis of the selected existing assessment instruments follows and promotes the development and evaluation of our HEI-specific GDPR assessment tool. Finally, conclusions are drawn and an outlook on future research is given.

GDPR Background

As stated by Albrecht (2016), GDPR will not only change Europe, but the world. The intention behind the GDPR is related to the protection of natural persons (individuals) with regard to the processing of their personal data. To achieve this objective, in 2018 the new regulation became enforcable to catch up the threats of cyber-attacks and to respond to those threats and ensure future resilience (Krystlik, 2017).

One of the changes compared to the GDPR's predecessor Data Protection Directive 95/46/EC is the extended territorial scope (Tikkinen-Piri, Rohunen, & Markkula, 2018). According to Article 3, GDPR is obligatory for organizations established in the EU, but also applies to organizations located outside of the EU if they offer goods or services to EU residents or monitor the behaviour of individuals in the EU (Tikkinen-Piri et al., 2018). In simplified terms, GDPR governs any organization that processes personal data of EU individuals – referred to as 'data subjects.' Based on this, HEIs outside the EU, e.g. in Switzerland, may also be subject to the GDPR if they handle data of persons such as students living in an EU member state.

Any organization affected by GDPR, needs to adhere to the following key principles (ICO, n.d.; Tikkinen-Piri et al., 2018): data processing must happen in a lawful, transparent, fair manner that ensures appropriate security and data collection has to be reduced to the minimum necessary in relation to the processing purpose. In addition, personal data shall be accurate and kept in a form that permits identification of individuals no longer than required. Finally, the accountability principle requires organizations to take responsibility and demonstrate compliance.

In addition to these principles, noteworthy developments with regard to consent lead to the necessity, amongst other things, for consent to be given freely and to reflect a specific, informed and explicit indication of the wishes of the data subject (Tikkinen-Piri et al., 2018).

According to the Information Commissioner's Office (ICO), the UK's supervisory authority, the obligations under the GDPR vary depending on the role an organization is assuming. A HEI would usually be considered as a 'data controller,' referring to a person or an agency that decides on the goals of personal data processing. Being a data controller comes with a high level of compliance responsibility – not only for oneself but also for potential processor(s), persons or agencies that carry out data processing on behalf of a controller (ICO, n.d.).

GDPR expands the data subject's rights. This includes the right to access information held on the data subject and the right to object to the processing of personal data where there are legitimate grounds for doing so (Tankard, 2016). As a further example, the right to be forgotten requires data controllers and processors to remove data that is no longer relevant or is considered to be inadequate or irrelevant (Tankard, 2016). Besides the data subject rights (for which a full list will be provided in section 4 of this paper), GDPR imposes enhanced obligations on data processors and controllers. As an example, appropriate technical and organizational measures to ensure data protection, such as encryption, are required (Tikkinen-Piri et al., 2018). In Article 25, GDPR sets out the concept of 'data protection by design and default' and Article 30 describes the obligation to maintain records of processing activities (Tikkinen-Piri et al., 2018). The obligations will be covered in more detail throughout this study.

A lot of attention in media has focused on the sanctions for not complying with GDPR (Garber, 2018). According to Article 84, companies can be fined up to 20 million euros or 4% of the total worldwide annual turnover, whichever is higher (Tankard, 2016). Hence, any Swiss HEI affected by GDPR should be concerned with the conformity to the law. Beyond the avoidance of fines, GDPR can also be seen as an opportunity to improve data processing practices and safeguards that strengthen stakeholder confidence and avoid business disruption (Garber, 2018).

The Data Protection Commission, the national independent data protection authority in Ireland, divides the GDPR into specific areas that need to be tackled during implementation (Data Protection Commission, 2017, p. 8). These seven areas are:

- Personal Data Collection
- Data Subject Rights
- Accuracy and Retention
- Transparency Requirements
- Data Controller Obligations
- Data Security
- Data Transfer (if applicable)

This study uses these seven areas as high-level topics when setting up the prototype of a GDPR assessment instrument and they will be discussed in detail in the following sections.

Existing GDPR Approaches and Assessment Instruments

After an introduction to GDPR, this chapter focuses on the specific requirements that the law places on HEIs. To achieve this, three alternative approaches towards GDPR compliance dedicated to the needs of HEIs are presented, one by Microsoft (2018), another by Podnar (2017) aimed at American HEIs, and the last one by the UK author Cormack (2017). In addition, some existing GDPR assessment instruments will be introduced – not focused on dedicated industry needs – that serve as a source for the development of the prototype.

Recommendations towards GDPR Compliance for HEIs

Microsoft released a guide for educational institutions on GDPR. In this guide, the authors defined two bodies of data in HEIs: the curriculum and the organization's information collection about employees and students (Microsoft, 2018). The Microsoft guide offers a variety of challenges and recommendations that revolves around four key steps:

1. *Discover:* a HEI must identify what personal data it holds and where. One challenge here is to document the way the data is processed in a GDPR-compliant method. Another issue is keeping track and checking the bandwidth of the devices on which data is stored, something that can be difficult if a non-managed cloud is included.
2. *Manage:* personal data must be governed. It is vital to identify the reason behind each data collection and question if it is necessary for the education delivery process in each HEI. The challenge here is to meet the strict GDPR rules on securing data across multiple data sources that a HEI uses – such as USB sticks, paper files in

cabinets, and others. Moreover, HEIs must be transparent on which personal data they collect when new students register and identify if this data is needed to fulfill their missions.

3. *Protect:* a HEI must have security standards in place to detect and prevent data breaches. This includes encrypting emails, adding rights to individual files and, most importantly, educating students and staff on cybersecurity and best practices when they use external devices to access their HEI's data. It is essential to remember that GDPR is an ongoing journey and not a destination. Therefore, a HEI should also conduct regular testing and constantly evaluate the effectiveness of their cybersecurity measures.
4. *Report:* as required by GDPR, a HEI must have the suitable documentations, respond to data access requests and report data breaches if they occur. GDPR hands over the responsibility of safeguarding personal data to the organization. Thus, a HEI must demonstrate its compliance with GDPR requirements. A HEI should facilitate data protection impact assessments (DPIAs), maintain audit trails, and track the flow of data to third parties when conducting audit trails. Moreover, a HEI should be able and have the necessary tools to respond to data breaches and report them within 72 hours to the authorities as required by GDPR (Microsoft, 2018).

Podnar (2017), a digital governance adviser, suggests an alternative approach for the GDPR compliance journey adapted to HEIs. The recommendations begin by conducting an audit on the HEIs' data. HEIs must document the location of data storage, the type of data collected, who has access to that data, and the reason for its collection. Some examples of the type of data HEIs typically collect, which need to be considered for the audit process, are (Podnar, 2017):

- Academic records,
- Alumni donations records,
- Students' pictures and other information used in students' IDs, even health data,
- Records of the use of websites and other tools offered by HEIs to students and researchers.

The second step deals with the lawfulness of data processing, whereas it is especially relevant to recognize the touchpoints where a consent, as one of the six possible lawful bases, is required (The European Parliment and The Council, 2016, Art. 6). The approach suggests a mapping of all the personal data that a HEI collects to determine the points at which consent should be collected. The third step of Podnar's approach is to develop 'a GDPR-compliant copy' of the consent and the required notifications including, among other things, the reasons for data collection along with the duration of the processing. Moreover, the data subjects must be informed of their rights to remove or access to their data (The European Parliment and The Council, 2016, Art. 30). Next, Podnar recommends HEIs to develop a communication plan. This is related to Article 33 of the law obliging data controllers to report personal data breaches that are likely to result in a risk to the rights and freedoms of individuals to the supervisory authority within 72 hours after detection.

As a final step, a HEI needs to decide if a Data Protection Officer (DPO) is required or not. Though the approach does not specify how to determine whether a HEI needs a DPO, according to Article 37, a DPO is obligatory for public bodies. Therefore, if a HEI is public, then a DPO is mandatory. However, it is relevant to recognize Article 27, which refers to data controllers who are not established in the EU, as in the case of Swiss HEIs. According to this Article, a so-called 'representative' has to be designated, whereas the obligation does not apply to public authorities or bodies (The European Parliment and The Council, 2016, Art. 27).

Turning to the recommendations of another author, Cormack (2017) regards the increased accountability regarding data held by HEIs as a significant change to GDPR. The author advocates that HEIs must have adequate measures in place to ensure the security of the information about students and employees.

In total, there are seven steps that HEIs must take to become ready for GDPR:

1. *Prepare:* Cormack (2017) suggested that the first step is to spread awareness of GDPR throughout the HEI. The GDPR assessment instrument being developed as a result of this study would be an instrument to support this preparatory phase of awareness building.
2. *Be in the know:* The HEI must document and be informed of the data it holds, and the source of that data, and have a plan in the event of a data breach. This step concerns the principle of accountability.
3. *Assign a DPO:* An internal or external employee who has the appropriate knowledge to ensure compliance with GDPR should be assigned as a DPO. As Cormack is targeting HEIs in the UK, this would be mandatory; however, exceptions could possibly apply to non-EU controllers (see our remark related to the data protection representative).
4. *Review privacy notes:* HEIs must reconsider their privacy agreements and make sure that the process of collecting personal information from students and employees is legal, time limited, and compliant with the required GDPR rules. This step is connected to the lawfulness

of data processing. Some processing activities might be covered by a contract or public, legitimate and vital interest. However, in case such a legal base is missing, data subjects must be asked for consent.

5. *Ensure that an individual's rights can be upheld:* Data subjects, be it students, parents or employees, have many rights under the GDPR, such as: have faulty information corrected, forbid direct marketing, have their data deleted, and move their data to another institution (data portability).
6. *Review how consent is given:* A HEI must ensure that the way it collects consents from its data subjects is in accordance with GDPR. For example, consents must be freely given, specified for only one processing, and cannot be implied by inactivity, such as a pre-checked box in an online form.
7. *Data breach drills:* Unless the personal data breach is unlikely to result in a risk to the rights and freedoms of natural persons, HEIs must inform the supervisory authority within 72 hours after having become aware of the event (The European Parliment and The Council, 2016, Art. 33).

This study takes into account the three approaches presented in setting up the GDPR assessment instrument for HEIs in Switzerland.

Existing GDPR Assessment Instruments

There exist already several GDPR assessment instruments for organizations, such as the ICO's data protection self-assessment (ICO, n.d.), the online 'quick-check' from the Swiss organization Economiesuisse (n.d.) or the self-assessment of the German (Bavarian) authority for data protection (BayLDA, n.d.). Those instruments are focused on a specific target group and of limited relevance for HEIs. In the following, we introduce two instruments, which we selected and used as a foundational source for the intended GDPR assessment instrument; we selected both because of their high maturity.

ISACA Assessment Instrument

The first instrument investigated more deeply is the 'ISACA-CMMI GDPR Assessment.' It was chosen because ISACA is a very well-established organization with huge expertise in the field – among others – of data privacy, governance and compliance. The instrument 'provides users with a roadmap for GDPR implementation based on the answers to a series of questions/statements' (ISACA, n.d.). ISACA's solution consists of privacy-related questions, each one mapped to the corresponding GDPR law articles. As an example, there is a statement focusing on the obligation to maintain a register of data processing activities (The European Parliment and The Council, 2016, Art. 30): ‘Personal data is documented in terms of their metadata in a register that is auditable and complete. The register provides a definitive record of what is processed and why.’ (ISACA, 2018). Additionally, a reference to various principles from ISACA’s well-established IT control frameworks is given (e.g., COBIT5 framework for strategic enterprise governance of IT).

Each question of ISACA’s GDPR assessment can be answered in four different ways according to ‘fully achieved,’ ‘largely achieved,’ ‘partially achieved’ or ‘not achieved.’ Besides these options, it is possible to skip questions or to mark them as not applicable (ISACA, 2018). After the online questionnaire is completed, a comprehensive summary report will be compiled with the possibility to download. The evaluation divides the various GDPR-questions into categories and indicates the resulting state using text along with amplification. The text contains advice as to what needs to be done to comply with the law.

Even though ISACA’s solution is comprehensive, the instrument might not be easy to use by non-specialists in the organization, due to its lengthy legally-based questions. Each question of ISACA’s instrument belongs to one or more GDPR articles and can contain up to eight articles in the same question.

Irish Data Protection Commission Checklist

The checklist from the Irish GDPR supervisory authority was chosen because of the compact nature of the instrument, and the similarity to ISACA, yet in a more easy-to-use form. It is a questionnaire-based guide divided into several sections, grouping GDPR-related questions. In contrast to the ISACA instrument, the Data Protection Commission questions have to be answered with either ‘yes’ or ‘no’ (Data Protection Commission, 2017). Moreover, the questions in the Data Protection Commission checklist are shorter and each belongs to one or two articles of the GDPR. An extra column is provided in the instrument for comments or remedial actions. However, the Data Protection Commission solution did not address some details such as third-party management. Still, the instrument has overlaps with the ISACA solution and includes similar questions.

Development of a GDPR Assessment Instrument for HEIs

In this chapter, we will present the steps of the development of our prototypical GDPR assessment instrument for Swiss HEIs. Based on selective concepts, existing recommendations and instruments presented, three stages were identified for a complete GDPR assessment.

1. *Check GDPR applicability:* In this stage, a HEI should first ensure whether it is under the scope of the GDPR. This stage's outcome must be a simple 'yes' or 'no.'
2. *Assess GDPR readiness:* In this stage, a DPO, or if not existent, a similar function, should answer questions associated with GDPR in order to get a result that indicates the HEI's readiness level to comply with the law.
3. *Act towards GDPR compliance:* In this stage, a HEI should act upon the result of the previous assessment. This stage is not in the scope of the current study.

The prototype developed adapts parts of the existing GDPR assessment instruments and combines them into an instrument for HEIs residing outside EU – Switzerland was chosen as a concrete unit of analysis. Due to their compactness and simplicity, the general outlines of the Data Protection Commission checklist were adopted. However, many of the ISACA instrument's controls have been used to fill any gaps the Data Protection Commission instrument missed. To tailor the instrument to HEI's needs, the majority of questions required an adjustment. Process models of each stage were created as a new element, using Business Process Model and Notation (BPMN) 2.0. They are designed to help users go through the assessment in the intended order (Figure 2).

Stage 1: Check GDPR Applicability

The first stage of this assessment instrument is to identify whether GDPR applies to a specific HEI or not. In his publication, Varankevich (2017), a data privacy officer and GDPR consultant, introduced a flow chart that can be used to determine the applicability of GDPR to any organization. If the outcome of this part is 'GDPR does not apply' then the rest of the assessment instrument is optional for the HEI. However, it is worth mentioning that also non-EU countries might adapt their current data protection regulation in the future. For example, Switzerland is currently undergoing a review of the federal data protection law, and it is expected to show close similarities to GDPR (PwC, 2018). Therefore, compliance with GDPR will nevertheless be a good preparation for HEIs. On the other hand, if the outcome of this check is 'GDPR applies,' then the next step is to start with stage 2.

Stage 2: Conduct Detailed GDPR Assessment

In the second stage, a HEI must go through all the assessments in the intended order. The order of the assessments was chosen from the Irish checklist (Data Protection Commission, 2017) and will be explained in the following.

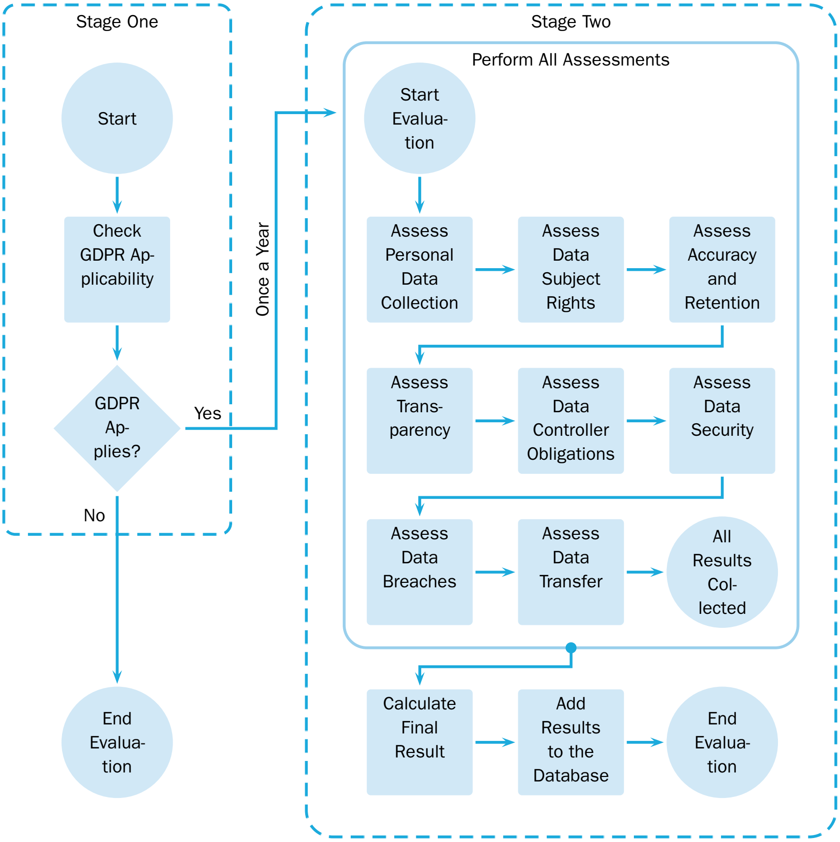


Figure 2 GDPR Assessment

Assess Personal Data Collection

In this process, several questions regarding the HEI's collection of personal data and corresponding lawful bases need to be answered. Initially, it is crucial to analyze which categories of GDPR-relevant personal data are concerned. Podnar (2017) proposes to evaluate whether visiting students from EU Member States are enrolled at the HEI or vice versa, and whether domestic students are spending a semester abroad at an EU higher education institution. In addition, professors, administrative, support or other EU staff working for the HEI should be considered. Cases where research funds from EU countries or donations from alumni students in the Union are received should be assessed as well.

Each processing of personal data needs to be based on legal ground, which could be a contract, legal obligations, and vital interests of the data subject, public interest, legitimate interest or consent (The European Parli-

Table 2 Assess Personal Data Collection

No.	Assessment question	Adapted from
Q1.5	Are consents, once obtained, appropriately documented and maintained?	ISACA (2018)
Q1.6	Does your HEI offer a way for individuals to withdraw their consent?	Data Protection Commission (2017)
Q1.7	Do you have documented and enforced privacy and security policies (and supporting procedures) to collect only the personal data that are adequate, relevant and limited to what is necessary in relation to the purposes for which the data are processed, in support of data-minimization requirements?	ISACA (2018)

ment and The Council, 2016, Art. 6). The latter case needs to meet special conditions (Art. 7). Any controller – the HEI in this case – must provide evidence of the data subject's (e.g., student's consent). This part of the GDPR assessment instrument is designed to assess the conditions for consent-based processing. Some example questions of this assessment are shown in Table 2.

Assess Data Subject Rights

One of the main objectives of GDPR is to provide individuals, the data subjects, with a wide array of rights that ensure the protection of their personal data. This part of the GDPR assessment instrument must ensure that a HEI has the correct procedures to cover the rights of data subjects as required by GDPR. It should be noted that these rights can be requested by any student, employee or other natural person in the EU from whom the HEI processes personal data and that the HEI should act within one month (The European Parliment and The Council, 2016, Art. 12). These rights are summarized in Table 3.

Assess Accuracy and Retention

According to UKs ICO (n.d.), the accuracy principle in GDPR promotes an obligation for organizations to take the appropriate steps to ensure the accurateness of the personal data they collect. GDPR did not define the term 'accurate.' However, according to the UK's Data Protection Act, 'inaccuracy' means that data is 'incorrect or misleading as to any matter of fact' (The National Archives, 2018, p. 122). Moreover, GDPR aims to ensure that the personal data that an organization keeps, where necessary, must be up to date (The European Parliment and The Council, 2016, Art. 5) and data subjects have the right to rectification (see Table 3). On the other hand, data must not be kept longer than it is required for any legal purpose (Art. 5). This means, that any HEI should familiarize itself with legal retention peri-

Table 3 GDPR Data Subject Rights

Right	Details
Right to be Informed	Data subjects, e.g., students, have 'the right to be informed about the collection and use of their personal data.' (ICO, n.d.)
Right of Access	Data subjects have the right to receive access to their own data and to obtain a copy from the HEI.
Right to Rectification	A HEI must rectify inaccurate data of students, employees and other natural persons from whom they process data on request.
Right to be Forgotten	Data subjects have the right to ask for deletion of their personal data, which the HEI needs to follow under certain circumstances (e.g., in case data is needed to comply with legal obligations such as a retention period, the law does not apply)
Right to Restrict Processing	In certain circumstances, such as the unlawfulness of data processing, the HEI is obliged to restrict the processing of personal data on the data subject's request.
Rights Related to Automated Decision Making	Data subjects, e.g., students, have 'the right not to be subject to a decision based solely on automated processing, including profiling, which produces legal effects concerning him or her or similarly significantly affects him or her.' (The European Parliment and The Council, 2016, Art. 22)
Right to Object	In certain circumstances, such as direct marketing a HEI might conduct, individuals have the right to object to the processing of their personal data.
Right for Data Portability	Data subjects must have the possibility to transfer their data to another HEI upon request.

Notes Questions adapted from Data Protection Commission (2017) and ISACA (2018).

Table 4 Assess Accuracy and Retention

No.	Assessment question	Adapted from
Q3.1	Do you have documented and enforced privacy and security policies (and supporting procedures) to ensure that personal data are kept accurate and up to date, as necessary, and to correct personal data errors without delay?	ISACA (2018)
Q3.4	Does your HEI have procedures in place to ensure personal data is destroyed securely, in accordance with your retention policies?	Data Protection Commission (2017)

ods for any personal data they store. Table 4 provides an extract of questions.

Assess Transparency

In this part of the GDPR assessment instrument, the openness and transparency requirements of GDPR are laid out. In simple terms, the students, employees and further data subjects of a HEI must be informed about the use of their personal data (Cormack, 2017). Additionally, a HEI must also inform its data subjects about their privacy rights 'in writing, or by other

Table 5 Assess Transparency

No.	Assessment question	Adapted from
Q4.2	Where personal data is collected directly from the individuals (such as students, alumni, researchers), are procedures in place to provide the information listed at Article 13 of the GDPR?	Data Protection Commission (2017)
Q4.3	Do you have documented and enforced policies (and supporting procedures and processes) to communicate to data subjects their rights, and answer their questions and provide information to them relating to data processing, in a manner that is clear, easy to understand, and age appropriate to the data subject (such as students, parents, researchers)?	ISACA (2018)

Table 6 Assess Controller's Obligations

No.	Assessment question	Adapted from
Q5.1	Have you published the contact details of your DPO to facilitate your students, employees or any other data subject in making contact with them?	Data Protection Commission (2017)
Q5.4	Does your HEI have agreements with suppliers and other third parties processing personal data on its behalf? If yes, have these agreements been reviewed to ensure all appropriate data protection requirements are included?	Data Protection Commission (2017)

means, including, where appropriate, by electronic means' (The European Parliment and The Council, 2016, Art. 12). Moreover, every HEI should have procedures to answer its students,' employees' and other individuals' requests regarding the personal data it withholds. A selection of questions to assess transparency can be found in Table 5.

Assess Controller's Obligations

There are other obligations that a HEI must consider when intending to become GDPR-compliant. One of these obligations is to investigate whether the HEI needs to assign a DPO or not. This part of the assessment instrument is divided into two sub-processes. The first process checks the necessity for a DPO assignment, while the second part checks other obligations such as agreements with suppliers, DPIAs, and the way a HEI handles the DPO if needed (see Table 6 for an extract of questions).

Assess Data Security

According to GDPR, it is the HEI's responsibility to secure its processing of personal data by means of 'appropriate technical and organizational measures' against damage, theft, or destruction (The European Parliment and The Council, 2016, Art. 5, 24). According to Article 32, there are several safeguards that every organization must consider when protecting the personal data it holds. One of these measures is pseudonymization, which

Table 7 Assess Data Security

No.	Assessment question	Adapted from
Q6.8	Can access to personal data be restored in a timely manner in the event of a physical or technical incident?	Data Protection Commission (2017)

is a technique that insists on protecting privacy by replacing real names or identifiers for data subjects (Tinabo, Mtenzi, & O'Shea, 2009). Another technique that is recommended by GDPR is the encryption of personal data. Moreover, GDPR states that it is the controller's – in our case the HEI's – responsibility to ensure the ability to restore and recover data in the event of damage, loss or physical incident (The European Parliment and The Council, 2016, Art. 5, 32). Table 7 shows a sample question belonging to this part of the assessment instrument.

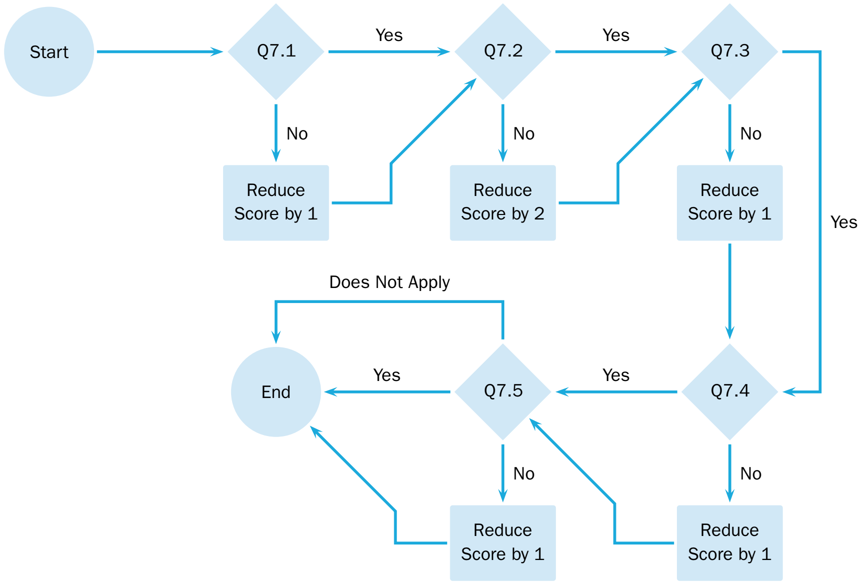
Assess Data Breaches

GDPR introduces an obligation of organizations to notify data subjects and relevant supervisory authorities in case of a personal data breach likely to result in a risk to the rights and freedoms of natural persons (The European Parliment and The Council, 2016, Art. 33). This notification must take place within the first 72 hours of its discovery (Tankard, 2016). Therefore, a HEI must have a documented plan that includes the GDPR requirements for data breach policies. According to ICO (n.d.), preparing a data breach plan entails: (1) Knowledge of how to detect a data breach. (2) Understanding of what is classified as a data breach, for example, students' grades qualify as breached in many cases. (3) A response plan for addressing breaches if they occur. (4) Allocation of responsibility to a designated person to manage breaches. (5) Awareness of the staff of escalating any incident to the designated person. These considerations result in specific checks for HEIs outlined in Figure 3.

Assess Data Transfer

If a Swiss HEI transfers personal data to any party outside the EU, e.g., partner universities to support exchange semesters, many conditions must be applied under the GDPR. Examples are:

- The foreign university or other partner must be in a country that ensures an 'adequate' level of protection (The European Parliment and The Council, 2016, Art. 45). Although the term 'adequate' is not explicitly defined, there are some controls for assessing the level of protection, such as the rule of law, or human rights in the country of processing, i.e. the country of the partner university in this case. It is



Q7.1 Does your HEI have a policy to define what is considered a data breach?
Q7.2 Does your HEI have a response plan to data breaches?
Q7.3 Does this plan ensure notifying the supervisory authority within 72 hours if a breach takes place?
Q7.4 Are all data breaches fully documented?
Q7.5 Is there any cooperation with other partners to deal with data breaches?

Figure 3 Visualization of 'Assess Data Breaches' Part of the GDPR Assessment Instrument for HEIs (Adapted from Data Protection Commission, 2017; ISACA, 2018; Varankevich, 2017)

recommended to check for any 'adequacy decisions' made by the EU Commission (ICO, n.d.)

- The HEI must implement safeguards to ensure the minimization of risks that surrounds the transfer of personal data (ICO, n.d.). According to Tikkinen-Piri et al. (2018), safeguards do either not require any specific authorization from a supervisory authority (such as standard data protection clauses adopted by the European Commission) or they can be used based on an authorization (for example, in case transfers are based on contractual clauses between the controller or the processor and the recipient).

This is the final check of the GDPR assessment instrument. It questions the user's HEI about the previous conditions along with some other requirements such as the documentation of data transfers (see a selection of questions in Table 8).

Table 8 Assess Data Transfers

No.	Assessment question	Adapted from
Q8.1	Does your HEI transfer data outside the European Economic Area? If yes, are all personal data transfers documented?	Data Protection Commission (2017)
Q8.4	Are data subjects fully informed about any intended international transfers of their personal data?	Data Protection Commission (2017)

Assessment Results

Answering all of the GDPR assessment instrument's questions and tracking the process models leads to a final assessment result. The prototype version is designed to let a HEI start with a score of 44 points and end up with a resulting number between 0 to 44. As it becomes visible in Figure 3, any answer that indicates non-compliance with a GDPR regulation leads to a score deduction, which might be weighted with one or several points. It is important to stress what this overall assessment score should not indicate: it should not express a dedicated level of compliance, such as being 'half or two third compliant.' Instead, if the assessment is conducted on a regular basis, the overall score is an estimation that supports the progress a HEI has made on its GDPR journey.

Conclusion and Outlook

The contribution of this study is the development of a prototype for a GDPR assessment instrument that can be used by HEIs in Switzerland, but also by other HEIs residing in a non-EU state, to provide an insight into a HEI's GDPR readiness (represented as a total score).

The prototype is intended to be a supporting instrument for experienced users in the field of data protection or DPOs when they carry out a low-threshold assessment in connection with GDPR requirements. Overall, the complete prototype consists of the following parts: firstly, an Excel-based sheet that contains all the questions of the assessment instrument numbered and colour-coded to match their respective process models. Secondly, a document is provided containing all the assessments of the two stages in the form of graphical process models, which is used to guide through the assessment. Finally, the prototype was tested and evaluated by compliance and modelling experts who concluded that the prototype is useful and can be used by data privacy personnel to assist any DPO in getting an overview of a HEIs readiness for GDPR.

Since this study is the first iteration of the development of the instrument, it is possible that some improvement could take place in the future. Several amendments were suggested by the participants of the evaluating workshop and should be taken into account in future developments such as digitizing the instrument and further evaluating the instrument based on lawyers' expertise. Moreover, GDPR deals with the protection of the data of European citizens, regardless of whether the organization generates profit from its data processing or not. As a potential further expansion, since this study deals with HEIs in an abstract way, the instrument could be adapted and generalized to fit any non-profit organization.

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Abstracts in Slovene

Od umetne do čustvene inteligence: povezovanje petih vrst inteligence z namenom doseganja organizacijske odličnosti

Chaojie Wang, Fred Hoffman, Alvi Lim in Jin Kwon

Sistemi za podporo odločanju so pomembni, saj se danes podjetja zatekajo k velikim podatkom (big data), strojnemu učenju in umetni inteligenci, da lahko usmerjajo razvoj strategij in izboljšajo organizacijsko uspešnost. Vendar tehnologija ni dovolj; človeška inteligenca je še vedno nujno potrebna. Ta članek predstavlja model umetne inteligence v povezavi s čustveno inteligenco, kar združuje tehnologijo in človečnost v podporo strateškemu odločanju. Model temelji na hierarhiji podatki-informacije-znanje-modrost (Data-Information-Knowledge-Wisdom) in upravljanju znanja za povezovanje petih vrst inteligence. Best Buy, eno večjih podjetij v maloprodaji potrošne elektronike pomaga pri ponazoritvi ustreznosti modela. Predstavljeni okvir ponuja močan miselni model, primeren za podporo organizacijskim strategom in vodjem podjetij.

Ključne besede: hierarhija DIKW, upravljanje znanja, tiho znanje, umetna inteligenca, poslovna inteligenca, konkurenčna inteligenca, odločitvena inteligenca, čustvena inteligenca

IJMKL, 8(2), 125–144

Digitalne neenakosti

Elena Fifeková, Eduard Nežinský in Andrea Valachová

Širjenje uporabe digitalnih tehnologij večini držav prinaša pomembne koristi. Te tako imenovane digitalne dividende pozitivno vplivajo na gospodarsko rast in širijo prostor za družbeno-ekonomski razvoj. Vendar zaradi neenakomerne porazdelitve digitalne tehnologije niso enako koristne za vse države in subjekte, posledično pa se postopoma poglablja digitalni razkorak, kar vodi v razlike v dohodkih med državami. Te je pozneje mogoče prevesti v druge družbeno-ekonomske značilnosti držav. V prispevku ocenjujemo stopnjo digitalizacije držav EU v okviru 62 svetovnih držav. Z metodo analize obsega podatkov (Data Envelopment Analysis – DEA) preučujemo, v kolikšni meri se neenakomerna porazdelitev digitalne pripravljenosti po državah odraža na stopnji njihove ekonomske učinkovitosti. Hkrati ugotavljamo potencialne digitalne izboljšave, s katerimi bomo izboljšali učinkovitost države.

Ključne besede: digitalne neenakosti, družbeno-ekonomski razvoj, analiza obsega podatkov, gospodarska rast

IJMKL, 8(2), 145–157

Raziskava šol kot učnih organizacij: teoretični pristop

Gabriela Alina Paraschiva, Anca Draghici in Constanta-Valentina Mihaila

Zaradi vse večjega pritiska na izobraževalno področje in da bi mladim bilo zagotovljeno znanje in spretnosti, potrebne za življenje in delo v nenehno spreminjajoči se družbi, ter trenutno neobstoječe tehnologije in trgovine, se je model organizacije učenja razširil na šole – kot poskus nove zasnove in preobrazbe organizacij, tradicionalno povezanih s postopkom učenja in znanja v organizacije, ki so se sposobne učinkovito odzivati na negotova in dinamična okolja. Namen tega prispevka je opredeliti stanje romunskega izobraževalnega sistema (preduniverzitetna raven), z namenom zagotavljanja izhodišča za izvajanje koncepta in modela »šole kot učne organizacije«. Pristop je teoretičen, z uporabo raziskovanja predpisov in podatkov o javnih izdatkih, namenjenih izobraževanju, financiranja na prebivalca, števila vpisanih učencev, rezultatov PISA in povezav med akcijsko usmerjenimi dimenzijami (z njihovimi ključnimi značilnostmi/elementi) predlaganega modela Kools & Stoll (2017), ter kazalnikov uspešnosti (vključno z deskriptorji), ki se uporabljajo na romunski nacionalni ravni. Rezultati kažejo, da so bile med letoma 2009 in 2018 šolske organizacije pod naraščajočim pritiskom, izvajanje tega koncepta in modela na sistemski ravni pa bi lahko predstavljalo priložnost, za osredotočanje na učence z organizacijske strani, pri čemer bi temelj predstavljale določene korelacije.

Ključne besede: učne organizacije, šole, izobraževalni sistem, uspešnost, kazalniki

IJMKL, 8(2), 159–178

Posredovalni učinek uporabe veščin na odnos med učenjem in nenehnim izpopolnjevanjem

Kristina Sisyuk

Potreba po nujni nadgradnji znanja zaposlenih se v političnih, socialnih in gospodarskih institucijah hitro povečuje. S tem je povezana nevarnost, da podjetja vlagajo v usposabljanje in razvoj zaposlenih brez ustreznega razumevanja, ki bi pripomoglo k dobremu sprejemanju trajnostnega učenja na delovnem mestu. Ta študija je raziskala posredovalno vlogo uporabe veščin v odnosu med učenjem in nenehnim izboljševanjem v na znanju temelječem podjetju. Za izvedbo analize posredovanja z modeliranjem strukturnih enačb po metodi zagona smo uporabili anketo iz leta 2015, izvedeno na vzorcu 3.730 zaposlenih v na znanju temelječem podjetju. Analiza je potrdila, da ima učenje vpliv na nenehno izboljševanje, saj vpliva na uporabo veščin. Raziskani učinki so statistično pomembni in pozitivni. Rezultati zagotavljajo empirično podporo vlogi posredovanja in pomembnosti uporabe veščin z namenom predstavitve koristi učnih ukrepov na delovnem mestu. Ta raziskava je za organizacije, ki temeljijo na znanju, pomembna kot način za razumevanje dejstva, da zgolj učne dejavnosti na delovnem mestu ne zadostujejo za stalno izboljševanje procesov, izdelkov in načinov dela.

Ključne besede: človeški kapital, usposabljanje v podjetjih, trajnostno učenje, nenehno izboljševanje

IJMKL, 8(2), 179–194

Upravljanje podatkov, povezanih z gradbeništvom: različni vidiki razvrščanja in opisovanja podatkov

Janne Harkonen, Erno Mustonen in Harri Haapasalo

Izboljšave produktivnosti v gradbenem sektorju zaostajajo za tistimi v drugih panogah. Možen dejavnik je narava dela - gradnja na kraju samem, ki morda ne omogoča tako industrijskega načina delovanja kot gradnja izven njega. Tudi delitev v okviru neoptimizirane verige področij arhitekture, inženiringa, gradnje in upravljanja objektov lahko odigra del vloge v celotnem procesu. Objekti gradnje ne veljajo za izdelke, ki bi potrebovali skrbno preučevanje strukture, ne s komercialnega, ne s tehničnega vidika, z namenom optimiziranja uporabe platform, sklopov, sestavnih delov in materialov – hkrati pa ponujali, kar kupci želijo. Poleg tega življenjski cikel grajenih objektov in različne potrebe med načrtovanjem, gradnjo in fazo uporabe niso dovolj učinkovito prepoznani. Preučevanje življenjskega cikla objektov gradnje zahteva nadzor nad ustreznimi podatki in razumevanje širše slike. Trenutno je organizacija upravljanja podatkov slaba. Cilj študije je oblikovati predpogoje za upravljanje podatkov, povezanih s gradbenimi objekti. Študija je izvedena kot kombinacija pregleda literature in analize ponudbe gradbenikov, načrtov zahtev, poročil ministrstva in dokumentacije glede nadzora stavb. Predstavljen je precej podroben primer upravljanja podatkov o gradbenih objektih z namenom razprave o glavnih podatkih, kot tudi o podatkih, povezanih s poslovnimi procesi in poslovnimi aplikacijami, ter različnih konfiguracijah obračunskih materialov (Bills-of-Materials – BOM), z namenom opozoriti na vse, o čemer bi bilo treba natančneje razmišljati. V okviru primera so poleg strukture izdelkov prepoznani tudi potrebni parametri in deležniki. Pomembna spoznanja s širšim okvirom za vzpostavitev učinkovitega upravljanja podatkov v gradbeništvu so sestavni del tega novega prispevka.

Ključne besede: upravljanje podatkov, glavni podatki, poslovni podatki, gradbena industrija, konfiguracije BOM, struktura izdelka, poslovni procesi, poslovne aplikacije, produktizacija, upravljanje izdelkov

IJMKL, 8(2), 195–220

Ocena zasebnosti podatkov: zgleden primer visokošolskih ustanov

Ali Habbabeh, Bettina Schneider in Petra Maria Asprion

Evropska splošna uredba o varstvu podatkov (GDPR), ki je začela veljati maja 2018, obvezuje podjetja in s tem tudi visokošolske ustanove, da (ponovno) ocenijo svoje postopke upravljanja zasebnosti podatkov, zlasti obdelavo osebnih podatkov. Ker nov zakon prehaja na zunajteritorialno področje, morajo tudi visokošolske ustanove zunaj Evropske unije (EU) preučiti njegov vpliv in po potrebi sprejeti ustrezne ukrepe. V trenutni literaturi primanjkuje razprav in pristopov na temo, kako lahko visokošolske ustanove izpolnjujejo predpise GDPR. Namen te študije je torej analizirati znanstvene publikacije, da bi se oblikovalo dvoje: konsolidirana ustrezna priporočila in zahteve v okviru GDPR in instrument, ki bi visokošolskim ustanovam pomagal pri ozaveščanju o GDPR. Slednji je bil že oblikovan z uporabo znanstvenih smernic in predstavlja osnovo za skupno 44 nadzorov, ki soustvarjajo skupno oceno. Nastala vrednost lahko služi kot pokazatelj, da visokošolske ustanove ustrezajo predpisom GDPR. Poleg tega se lahko sestavljeni nadzori uporabljajo kot instrument upravljanja za oceno sprejetih ukrepov in za stalno spodbujanje skladnosti z GDPR.

Ključne besede: instrument za ocenjevanje, orodje za ocenjevanje GDPR, zasebnost podatkov, evropska splošna uredba o varstvu podatkov, visokošolske ustanove

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