IHF
Bayerisches Staatsinstitut für
Hochschulforschung und Hochschulplanung

Beiträge zur HOCHSCHULFORSCHUNG

3 | 2019

Special issue: blockchain, education technology, and agility

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Impressum

Beiträge zur Hochschulforschung
erscheinen viermal im Jahr
ISSN (Print) 0171-645X
ISSN (Online) 2567-8841

Herausgeber: Bayerisches Staatsinstitut für Hochschulforschung
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Graphische Gestaltung: Haak & Nakat, München

Satz: Dr. Ulrich Scharmer, München

Druck: Steinmeier, Deiningen

Ausrichtung, Themenspektrum und Zielgruppen

Die „Beiträge zur Hochschulforschung“ sind eine der führenden wissenschaftlichen Zeitschriften im Bereich der Hochschulforschung im deutschen Sprachraum. Sie zeichnen sich durch hohe Qualitätsstandards, ein breites Themenspektrum und eine große Reichweite aus. Kennzeichnend sind zudem die Verbindung von Wissenschaftlichkeit und Relevanz für die Praxis sowie die Vielfalt der Disziplinen und Zugänge. Dabei können die „Beiträge“ auf eine lange Tradition zurückblicken. Die Zeitschrift erscheint seit ihrer Gründung 1979 viermal im Jahr und publiziert Artikel zu Veränderungen in Universitäten, Fachhochschulen und anderen Einrichtungen des tertiären Bildungsbereichs sowie Entwicklungen in Hochschul- und Wissenschaftspolitik in nationaler und internationaler Perspektive.

Wichtige Themenbereiche sind:

- Governance von Hochschulen und Forschungseinrichtungen,
- Steuerung und Optimierung von Hochschulprozessen,
- Hochschulfinanzierung,
- Qualitätssicherung und Leistungsmessung,
- Studium und Studierende, Umsetzung des Bologna-Prozesses,
- Übergänge zwischen Schule, Hochschule und Arbeitsmarkt,
- Forschung und wissenschaftlicher Nachwuchs, akademische Karrieren,
- Geschlechterungleichheiten in der Wissenschaft,
- Wissenschaft und Wirtschaft,
- International vergleichende Hochschulforschung,
- Wissenschaftsforschung.

Die Zeitschrift veröffentlicht quantitative und qualitative empirische Analysen, Vergleichsstudien, Überblicksartikel und Einblicke in die Praxis, die ein anonymes Peer Review-Verfahren (double blind) durchlaufen haben. Sie bietet die Möglichkeit zum Austausch von Forschungsergebnissen und stellt ein Forum für Hochschulforscher und Experten aus der Praxis dar. Neben Ausgaben, die das gesamte Spektrum der Hochschulforschung abbilden, erscheinen in regelmäßigen Abständen Themenhefte. Hierfür erfolgt in der Regel ein Call for Papers. Manuskripte können jederzeit in deutscher und englischer Sprache eingereicht werden.

Die „Beiträge“ richten sich an Wissenschaftler, die sich mit Fragen des Hochschulwesens und seiner Entwicklung befassen, aber auch an politische Entscheidungsträger, Hochschulleitungen, Mitarbeiter in Hochschulverwaltungen, Ministerien sowie Wissenschafts- und Hochschulorganisationen.

Alle Ausgaben der „Beiträge zur Hochschulforschung“ erscheinen in gedruckter Form und werden auf der Homepage unter www.bzh.bayern.de veröffentlicht, die einzelnen Artikel sind nach verschiedenen Kategorien recherchierbar.

Contents

Editorial

Universities are confronted with the need to undergo a digital transformation. This is a complex process, especially as universities today are faced with a global, knowledge-based society and highly mobile employees and students. Furthermore, a variety of models of future higher education are emerging such as; profit-oriented adult-centred universities, distance education universities, corporate universities, university-industry strategic alliances and global multinational universities. It is therefore more important than ever for institutions of Higher Education to anticipate necessary changes quickly at an early stage, and to react flexibly and proactively. This mindset of anticipatory management is called business agility and has a huge impact on change-intensive organisations such as universities.

Consequently, the Journal of Higher Education Research intends to bring blockchain, education technology and agility to the world of higher education and to examine the various application fields in a special issue.

Wiebke Lévy, Jutta Stumpf-Wollersheim, and *Isabell Welpe* analyse the use of blockchain technology in education on the basis of a qualitative content analysis of providers' websites. The authors conclude that blockchain technology has the potential to induce change in education, but that this technology is still at an early stage.

Kristin Vogelsang, Paul Greiff, Carla Tenspolde, and *Uwe Hoppe* examine recent research about changing learning conditions induced by technology-enhanced learning systems such as; open educational resources, social media systems, and massive open online courses. The authors state that they support agility by way of fast feedback, participation, and continuous improvement.

Fabian Schär and *Fabian Mösli* open insights into the practice by describing how blockchain technology can be used to secure academic credentials, based on a joint project between the University of Basel and a private company. They analyse how blockchain diplomas rank against other options and show what advantages, and disadvantages, the blockchain solution has.

Rainer Rehak opens a critical view into the use of decentralised ledger technologies like blockchain. He arrives at the conclusion that, as interesting as the blockchain vision technically is, it is no substitute for traditional political processes or democratic regulation of power.

Elena Wilhelm takes a look at the organisational concept of agility and explains how she understands the agility of a university against this backdrop.

Yvette Hofmann, Isabell M. Welpe, Lydia Hartwig

Disrupting education through blockchain-based education technology?

Wiebke S. Lévy, Jutta Stumpf-Wollersheim and Isabell M. Welpe

This study is the first to systematically analyse the use of blockchain technology in education. In particular, we analyse the status quo of blockchain-based education technologies (N = 62). We performed a qualitative content analysis of providers' websites to analyse the characteristics of their technologies. The analysis reveals that existing blockchain-based education technologies are diverse and offer important advantages for education (e. g., trust and equal opportunities). Employers seem to profit from these technologies (e. g., trust in applicants), but only some technologies contribute to the individualization of education. Current blockchain-based education technologies were primarily made for the general public or for job seekers. We conclude that blockchain technology might disrupt education but that this process of change is only in its infancy. Given the high relevance of this topic, we conclude by developing an agenda for future research.

1 Introduction

Because blockchain technology (a distributed and encrypted digital database) holds the potential to innovate education, both from the perspective of the digital transformation of education and from a social innovation perspective, it is critical to analyse the landscape of blockchain-based education technology (c. f., Grech & Camilleri, 2017; Iansiti & Lakhani, 2017; Tapscott & Tapscott, 2016). Changes in education enabled by blockchain technology may offer opportunities to digitalize current education and may increase the potential to disrupt education.

First, blockchain technology enables innovative opportunities in education that may induce digital transformation in education through decentralization and democratization (c. f., Kosba, Miller, Shi, Wen, & Papamanthou, 2016; Piscini, Guastella, Rozman, & Nassim, 2016; Zyskind & Nathan, 2015) and may even lead to disruption of brick-and-mortar education. Because of blockchain technology, the possibility of digitalizing educational services might become much more concrete than it has been in recent years (c. f., Chen, Xu, Lu, & Chen, 2018; Seebacher & Schüritz, 2017). Blockchain technology, frequently referred to as "the trust machine" (Tapscott & Tapscott, 2016), allows the storage of decentralized records that cannot be tampered with (Piscini et al., 2016; Swan, 2015; Zyskind & Nathan, 2015). Entries on the blockchain are permanent and accountable (Piscini et al., 2016).

These characteristics enable new opportunities in education and therefore a wide range of service innovations. For example, a variety of educational data can be stored on a blockchain. These data can range from single certificates to an individual's entire set of performance data (e.g., a certificate of a language course or a degree from a university). Due to its architecture as a digital network, blockchain technology also allows the retrieval of data (e.g., a person's educational achievements are securely stored) across all connected parties (c.f., Swan, 2015; Underwood, 2016). Because the blockchain technology makes it possible to issue and store certificates (i.e., through hashes and smart contracts), different facilities can provide education much more easily and learners can, for example, potentially earn a degree by combining courses from different facilities. Taken to the extreme, this possibility might lead to a fundamental change in the nature of universities as institutions by decoupling education from particular institutions. This decoupling of education is an example of blockchain technology's potential to cut out intermediaries (i.e., middlemen) and decentralize entire industries (Iansiti & Lakhani, 2017; Tapscott & Tapscott, 2016; Yli-Huumo, Ko, Choi, Park, & Smolander, 2016; Zyskind & Nathan, 2015). This decentralization of education technology could therefore lead to a so-called low-end disruption, meaning that blockchain technology-based education-technology providers enter the higher education market at the low end and replace universities (i.e., middlemen) (Christensen, McDonald, Altman, & Palmer, 2016).

However, these are only a few examples, and the possibilities for changing education through blockchain technology are manifold. For example, tokens can be used to motivate learners (Chen et al., 2018). A particular example is the platform Tutellus, which uses blockchain technology as a basis for tokens that users can earn through participation in the platform. Relatedly, there are also advantages for employers, who can place more trust in the legitimacy of the educational achievements of applicants. For example, the blockchain-based technology Apii is planning to use blockchain-technology to verify the curriculum vitae of applicants, which makes the recruitment process more transparent.

A second and closely related advantage, from a social innovation perspective, is that blockchain-based education technology can provide educational opportunities for learners in impoverished or developing countries (c.f., Underwood, 2016). Blockchain technology might therefore lead to a democratization of education. By offering the possibility of profiting from education to learners who, until now, did not have access to education, blockchain technology might enable a so-called new market disruption (Christensen et al., 2016). For example, blockchain technology allows the storage of a digital identity that can provide proof of education for learners in remote areas. In particular, finding a means by which to store educational data safely on a blockchain and being able to provide proof of education in such a way allows tremendous advantages for our society. For example, refugees' access to higher education in an entirely different country could be facilitated by storing proof of their educational achievements (e. g., university degrees, number of credits) with blockchain technology.

Previous research has established the vast innovative potential of blockchain-based technologies. For example, blockchain technology enabled new opportunities in the finance industry (e. g., cryptocurrencies or money transfer) (Friedlmaier, Tumasjan, & Welpe, 2017). In their review of the different technological areas to which blockchain is relevant, Yli-Huumo et al. (2016) found that only 20 % of the papers under investigation addressed blockchain-related issues other than cryptocurrencies. Further research reflects the current landscape of blockchain-based firms: Friedlmaier et al. (2017) analysed the entire landscape of blockchain-based firms and found that 42 % of the firms operated in the finance and insurance industry and 36.5 % in the information and communication industry. However, only 0.5 % of the firms operated in the education technology industry. Thus, it is not surprising that research on blockchain in the education technology industry is rather scarce. This scarcity is demonstrated in a recent review on blockchain-related research, which mentions the application of blockchain to education only briefly in the section titled "others" (Sharples & Domingue, 2016).

In the education technology context, Sharples and Domingue (2016) suggest that the academic community should use blockchain technology as a reward system and as a "permanent distributed record" (p.1) of intellectual accomplishments. Grech and Camilleri (2017) use case studies and unsystematic interviews to assess the potential of blockchain for learners. They assume that in the field of education, blockchain technology will disrupt the *"award of qualifications, licensing and accreditation, management of student records, intellectual property management* (see Sharples & Domingue, 2016) *and payments"* (p. 10). The authors further assume that the biggest advantages of blockchain technology for education are self-sovereignty, trust, immutability, disintermediation and collaboration. Similarly, Chen et al. (2018) explored potential applications of blockchain technology in education and concluded that this technology can be used for performance assessments and results in a decrease in information asymmetry, an increase in trust between educator and learner, and more authenticity.

Despite the merits of these few articles that focus on the education technology context, systematic empirical research on blockchain technology in education is thus far absent. In particular, we need an overview of the possibilities currently offered by blockchain-based education technology as well as an understanding of their characteristics to reveal their advantages. Through this analysis of the status quo of blockchain-based education technology, one can draw conclusions on the disruptive potential (i. e., which changes they might induce) of these technologies. This approach is particularly good, as disruption can hardly be predicted before it has occurred, and this paper therefore concentrates on the potential of blockchain-based technologies to induce change in education. This paper uses previous research (e.g., Chen et al., 2018; Grech & Camilleri, 2017) as a starting point and systematically analyses the blockchain-based education technologies that are available today and that will be released soon. We characterize blockchain-based education technology according to the following characteristics: the particular role the blockchain technology plays in education technologies; the functionality of those technologies (i.e., which aspect of education they might disrupt); and the advantages the blockchain-based education technology might provide for learners and potential employers. Moreover, we analyse the target group for which the technology is built (e.g., higher education). In sum, we assess the status quo of blockchain-based education technologies, which serves as a foundation for our research agenda for blockchain-based education technologies.

Our results allow us to determine whether the currently available blockchain-based education technologies qualify as facilitators of current brick-and-mortar education or as entirely new service innovations (c.f., Iansiti & Lakhani, 2017). From a practical point of view, our results address recent calls in the literature to raise awareness among educational stakeholders of the possibilities offered through blockchain-based education technologies (Chen et al., 2018; Grech & Camilleri, 2017).

This paper is organized as follows. We begin with a short introduction to the meaning of blockchain technology and its characteristics that are relevant to education technology. Subsequently, we explain our research method (i.e., a systematic assessment of venture databases performed to generate a conclusive sample of blockchain-based education technology applications, followed by a content analysis to retrieve information about the technologies). Finally, we present the results of our research and conclude with a discussion focusing on the meaning of blockchain technology for education and an agenda for future research.

2 Blockchain technology and its use in education

2.1 Blockchain technology

Blockchain technology was initially programmed for Bitcoin (i.e., a cryptocurrency). There are now various additional versions and applications of blockchain technology, such as Ethereum (Wood, 2014). This paper focuses on blockchain technology in general.

Attempting to understand the advantages of blockchain technology for education – compared to conventional ways of handling educational data – requires an understanding of the basic principles of blockchain technology. First, blockchain technology represents a distributed database (i. e., repository or ledger), which implies that blockchain technology is based on a peer-to-peer network (Iansiti & Lakhani, 2017; Zambrano, Seward, & Sayo, 2017). The database is shared with each party connected to the blockchain (i. e., a person with a computer connected to the blockchain). Each of these parties represents one node in the network (Cachin, 2016). Second, blockchain technology is based on consensus (i. e., using cryptographic algorithms; Kosba et al., 2016; Underwood, 2016), which signifies that each new record is verified through consensus algorithms (e. g., a proof-of-work algorithm in case of the Bitcoin blockchain). Each record has a digital signature so that it can be traced back to its source. Subsequently, the records are stored in a block of data and distributed to each node (Crosby, Pattanayak, Verma, & Kalyanaraman, 2016; Swan, 2015). Each added block of data represents a new block in the chain (i. e., the blocks are interlinked) (Underwood, 2016). The blockchain grows as more blocks are added and the blocks are interlinked through identifiers (Zambrano et al., 2017). The blockchain is therefore a decentralized network (Kosba et al., 2016; Zyskind & Nathan, 2015). Because of this decentralization of the records stored on the blockchain, the data are much harder to change than is the case when transactions are centrally stored with only one institution (e. g., a bank in case of money transferring; Friedlmaier et al., 2017; Iansiti & Lakhani, 2017; Piscini et al., 2016).

The main use of blockchain technology is to create trust between the involved entities (Mainelli & Smith, 2015; Underwood, 2016). In particular, because its records are very securely stored as well as traceable and linked to their origins, and because of the possibility to ensure the legitimacy of transactions between parties, blockchain technology allows the elimination of intermediaries. Such intermediaries might be banks in a bank transfer, lawyers in contracts (i. e., smart contracts) or, as in the context of this paper, educational institutions in learning (Iansiti & Lakhani, 2017; Yli-Huumo et al., 2016; Zyskind & Nathan, 2015). Without blockchain technology, these intermediaries need to ensure that transactions or contracts are trustworthy (Mainelli & Smith, 2015).

2.2 Characteristics of blockchain technology in the context of education technology

Different types of information can be stored using blockchain technology (i. e., records). Important forms of records are asset transactions (e. g., transactions of currency, to pay for education or tokens for successful learners; Crosby et al., 2016; Nakamoto, 2008), smart contracts (Cong & He, 2018; Kosba et al., 2016) and digital certificates or signatures (i. e., usually hashes referring to the certificate, e. g., educational certificates; Grech & Camilleri, 2017; Peters & Panayi, 2016). A particular form of such certificates that is important for education is documentary evidence of ownership rights. Because it offers the possibility to store these different types of immutable educational information on blockchain technology, blockchain technology is an important asset for education.

These different types of records can support education in different ways. First, blockchain technology in education can be considered a type or part of education technology. Education technology includes any technology that aims to facilitate learning (Januszewski & Molenda, 2008). The goal of such technology is to improve educational performance (e.g., online courses adapting to the learners' pace instead of face-to-face lectures; Januszewski & Molenda, 2008). Education technology offers new possibilities to deliver education and digitalizes education that was previously offline (c.f., Lusch & Nambisan, 2015). Being a type or part of education technology, blockchain technology supports learning and thus the core of education (e.g., by offering tokens to motivate learners). Second, blockchain technology can be used to support administrative functions in education, such as storing educational performance data (e.g., certificates). Through the possibility to store educational data, blockchain technology can, for example, connect learners to future employers. Third, blockchain technology can be used to protect intellectual property. In this case, the application of blockchain technology does not serve a strictly educational purpose. However, intellectual property is an important component of knowledge creation and thus of educational institutions.

The amplitude of the role of blockchain technology can vary. On the one hand, blockchain technology can serve as a component of education technology. This means that the education technology has a distinct main function (e.g., an online course) and blockchain technology supports part of this main function (e.g., offering tokens for learners within the online course). On the other hand, blockchain technology can be the main part of the education technology. For example, the blockchain may store the educational record of a learner. In this case, blockchain technology enables the creation of entirely new types of education technology.

In general, blockchain technology provides some key advantages for education compared to data stored in the usual way. Based on their analysis of the blockchain literature, Grech and Camilleri (2017) identify, for example, the following advantages: self-sovereignty (i.e., learners have control over their own performance record) and identity (i.e., being able to be identified online), trust (i.e., blockchain technology provides trust through its architecture as a decentralized ledger), immutability (i.e., the decentralized network on which the blockchain is based prevents the corruption of data by outside entities), and disintermediation (i.e., blockchain technology can replace middlemen such as education institutions) (Swan, 2017; Underwood, 2016; Yli-Huumo et al., 2016). We further assume that efficiency (e.g., through cutting out intermediaries), equal opportunities (e.g., censorship is not possible, and socially disadvantaged learners receive similar opportunities) and motivation (through tokens) are the main advantages that blockchain technology offers for education. These advantages are linked to each other and have their roots in the architecture of blockchain technology as a decentralized digital database.

However, all blockchain-based education technologies do not necessarily offer these advantages equally (Underwood, 2016). For example, a platform that saves educational data focuses on trust between learners and future employers, whereas a learning platform that hands out blockchain-based tokens to learners has a particular focus on enhancing learners' motivation. Through these advantages, blockchain technology might enable education technology to provide service solutions that education currently needs. Education is based on a "one-size-fits-all" principle, and blockchain-based education technology might allow more individualization. The changes induced by blockchain technology range from simple digitalization of current education to the disruption of education and therefore the provision of entirely new service solutions.

Blockchain-based education technologies might also be useful for employers, who can gain trust in applicants through the use of blockchain technology (e.g., certificates saved on blockchain technology). To understand blockchain-based education technology, it is necessary to distinguish among the main parties involved in blockchain technology (i.e., who is the main addressee of a particular technology, and who else might be involved in using it) (c.f., Kuvshinov et al., 2018). Blockchain-based education technology can focus on learners, educators or future employers (e.g., reducing degree fraud) (Chen et al., 2018). In addition, blockchain-based education technologies might facilitate learning for particular educational institutions (e.g., pre-school or university level).

3 Method

Table 1 provides an overview of the research procedure, which will be specified in the following sections according to these two steps.

Table 1: Research process.

Sample construction
– Database search
– Filtering of sample
– General search (white papers, etc.)
Qualitative content analysis followed by quantitative analysis
– Development of variables based on theory
– Adaptation of variables
– Data collection
– Descriptive analysis of results

3.1 Sample construction

We based the study on the analysis of the blockchain technologies themselves. The goal was to gain a deep understanding of the blockchain-based education technologies and their advantages and characteristics, which might allow them to induce change in education. To develop a full list of blockchain-based education technologies, we relied on the Crunchbase and Venture Radar databases to retrieve firms offering such technologies. Additionally, because some blockchain-based education technologies are currently being developed and therefore may not yet be included in official databases, we used Google to find newspaper articles and/or white papers, and we used provider websites to identify additional providers to include in our list. We retrieved 36 providers from Crunchbase. We used the search terms "blockchain" and "decentralized" in combination with eleven different search terms (namely, education, edtech, e-learning, intellectual property, document management, identity management, record, licensing, grant, recruitment, certificates) in the categories and descriptions of the providers. We retrieved possible search terms from Grech and Camilleri's (2017) analysis of the possibilities for using blockchain in education. In Venture Radar, we used the general term "blockchain" in combination with "education"; however, we did not identify any additional providers compared to those we retrieved from Crunchbase.

As the goal of this study is to assess providers that use blockchain for educational purposes (i. e., learning, administration or any support for learners in general), we filtered the list according to this definition and excluded providers that were not based on blockchain technology or had no educational purpose; we also excluded duplicates. This procedure resulted in 36 providers.

Subsequently, we systematized the Google search by using the search term "blockchain" in combination with "firm", "company" and "startup" and the eleven search terms we used in Crunchbase (see above). This procedure resulted in additional 26 providers. We screened the providers according to how well they fit our definition. Our final sample size is 62.

The 62 providers in our sample were from 25 countries. Most providers came from the United States ($N = 22$; 35.5 %) and from Europe ($N = 22$; 35.5 %), while 10 came from Asia (16.1 %) and 2 from South America (3.2 %; $N_{missing} = 6$, 9.7 %). Most providers had between 1 and 10 ($N = 22$; 35.5 % %) or between 11 and 50 ($N = 30$; 48.4 %) employees ($N_{other} = 3$, 4.8 %; $N_{missing} = 7$, 11.3 %). One provider was founded in 1980. The rest of the providers were founded between 2012 and 2018 ($M = 2015.49$; $SD = 4.83$; $N_{missing} = 1$, 1.6 %). A total of 12.9 % of the providers were financed through investors ($N = 8$), 19.4 % through initial coin offerings (i. e., crowdfunding through token sales/cryptocurrency, $N = 12$), and 4.8 % through both investors and initial coin offerings ($N = 3$). Information on funding type was not available for 62.9 % of the providers

($N = 39$), partly because the providers were still in a testing/beta phase ($N_{beta} = 16$, 25.8 %; $N_{alpha/testing} = 9$; 14.5 %) and not yet fully operating ($N_{Operating} =$ 30, 48.4 %; $N_{missing} = 7$; 11.3 %), and partly because it is difficult to retrieve this information for small providers. As a result, our sample includes fully operating firms as well as blockchain-based education technologies currently in development. A total of 58.1 % of the education technologies were based on Ethereum ($N = 36$), 3.2 % on Bitcoin ($N = 2$), 9.7 % on EOS ($N = 6$), and 1.6 % on NEM ($N = 1$); 1.6 % used a private blockchain ($N = 1$), 4.8 % could be used on more than one blockchain ($N = 3$) and 6.5 % used other blockchain technologies ($N = 4$; $N_{missing} = 9$, 14.5 %).

3.2 Qualitative content analysis followed by quantitative analysis

We chose a qualitative content analysis followed by a descriptive analysis of the results. By choosing this method, we aimed to filter out the most important characteristics and advantages of blockchain-based education technologies. The websites of the blockchain-based education technology providers were chosen as a source of information, as they describe the benefits and characteristics of the relative technology. Thus, this source of information was chosen as a means to retrieve a number of comparable and quantifiable variables.

We developed the variables using the following procedure: One part of the variables was based on current knowledge about blockchain technology in general and blockchain-based education technologies in particular. We added other variables due to the current context of education. The initial coding scheme was developed by the first author of this paper. Table 2 summarizes all variables, categories, and the origin of the variables.

During the coding of the providers, we added additional categories, but we also condensed highly similar or not distinguishable categories. We revised the categories four times based on the first 30 blockchain-based education technologies. In order to facilitate the coding, each variable was defined and categories were specified using a detailed description of their meaning and examples. [For a deeper understanding of the meaning of the variables, see the theory section.]

Information about the variables was retrieved from several sources: the websites describing the blockchain-based technologies, available white papers, Crunchbase and LinkedIn pages. It took between 20 minutes and 1 hour to assess the information for each blockchain-based education technology. One rater coded the variables, and a second rater verified the codings. Critical cases were discussed between the raters, and a joint decision was made.

4 Results

The results of the descriptive analysis are presented in Table 2.

Table 2: Description of codings and results.

Variable **Reference and definition** **Mean (SD) of number of codings[a]**	
Categories	**% (k)**
Main function of blockchain technology Grech and Camilleri (2017); i.e., what is the blockchain technology used for?; 3 (1.30)	
Formal and non-formal achievements	21 (37)
Intellectual property management	5 (8)
Currency: payments to institution	16 (28)
Currency: payments to learner	12 (21)
Rewards/payment for content creators	20 (35)
Student identity	1 (2)
Smart contracts	25 (44)
Main function of the education technology (self-developed); based on the descriptions of the education technologies, i.e., not always the same as the functionality of the blockchain technology; 1.65 (0.93)	
The education technology does not go beyond the function of the blockchain technology	20(20)
Learning platform (several courses)	24 (24)
Knowledge platform	2 (2)
Collaborative/peer-to-peer learning platform	13 (13)
Application platform for a particular institution	1 (1)
Game-based learning	6 (6)
Entire learning institution, e.g., a university	2 (2)
Social/professional network	10 (10)
Match/connect tutors and learners	1 (1)
Match/connect employer to candidates	20 (20)
Others	3 (3)
Type of records saved Grech and Camilleri (2017); 2.24 (0.84)	
Transactions of currency	33 (46)
Documentary evidence of ownership rights	6 (8)
Smart contracts	32 (45)
Digital signatures and certificates	29 (40)

To be continued

Table 2, continued

Variable Reference and definition Mean (SD) of number of codings[a]	
Categories	**% (k)**
Key advantages of blockchain technology Grech and Camilleri (2017); i.e., significant possibilities offered by blockchain technology that go beyond the possibilities currently available; 2.69 (1.11)	
Self-sovereignty and identity	8 (13)
Trust	24 (39)
Immutability	17 (27)
Disintermediation	13 (21)
Efficiency	17 (28)
Equal opportunities	7 (12)
Motivation	15 (24)
Does the technology help to individualize education? (self-developed); i.e., can learners receive individual education through blockchain technology instead of "one-size-fits-all" education?	
Not at all	77 (48)
Some individualization	16 (10)
Entirely individualized	7 (4)
Does the technology help to provide for the needs of future employers? (self-developed); 1.37 (0.61)	
Not at all	31 (26)
Provides more trust	34 (29)
Employees gain more knowledge	8 (7)
Finding more suitable candidates and/or finding candidates faster	27 (23)
Who is the addressee? (self-developed); i.e., who uses the technology?; 1.65 (0.68)	
Learners (i.e., members of a learning institution)	11 (14)
Teachers/instructors (i.e., for their own education)	2 (2)
General public (i.e., users who do not belong to an institution)	41 (52)
Institutions (i.e., for their own content)	10 (12)
Job seekers	28 (35)
Researchers	10 (12)
Who is the second user? (self-developed); i.e., who, besides the addressee, additionally provides something by using the technology or profits from the technology (e.g., addressee saves certificates, and an employer can verify them)?; 1.19 (0.46)	
Students (i.e., can serve as tutors)	1 (1)
Teachers/instructors	20 (15)
Institutions	4 (3)

To be continued

Table 2, continued

Variable Reference and definition Mean (SD) of number of codings[a]	
Categories	**% (k)**
Employers	39 (29)
Others	5 (4)
No second user	30 (22)
Target group (self-developed); i.e., if the technology has a direct learning function (e.g., learning platform), for which group of learners is the technology made?; 1.37 (0.70)	
Kindergarten or preschool	4 (3)
School	9 (8)
Higher education or college	18 (15)
Adults	25 (21)
Companies in particular	4 (3)
No direct learning function	41 (35)

[a] If several categories were applicable, the variables were assigned several categories. This was the case for all variables except for "Does the technology help to individualize education?". For these variables, the number (k) of codings and the percentage of codings therefore describe the absolute percentage of codings.

4.1 General function of blockchain technology and education technology

Very often, a blockchain technology serves as a means of recording formal and non-formal achievements (e.g., verifiable digital educational records), as a reward or payment for content creators (e.g., offering tokens to instructors involved in an online learning platform), and to produce smart contracts regulating demands and achievements (e.g., assignment and storage of certificates for successful completion of courses on the blockchain).

In 20 % of cases, the main function of the education technology did not go beyond the main function of the blockchain technology (e.g., the education technology offers instant issuance and authentication of digital records, which is congruent with the main function of the blockchain technology). An example is the technology Learning Machine which represents a credentialing system to issue records. The main function of this technology is entirely based on blockchain-technology. However, in the other cases, there was a difference between the underlying function of the blockchain technology and the function of the education technology.

In the largest proportion of the cases, blockchain technologies were used within learning platforms (e.g., an online learning platform using blockchain technology to provide learners with tokens and certificates), to match/connect employers to candidates (e.g., a platform to connect candidates and employers and to allow employers to access candidates' verified resume information through blockchain technology), within collaborative/peer-to-peer learning platforms (e.g., a peer-to-peer online learning platform using smart contracts to connect the learning community) and within social/professional networks (e.g., a professional network using blockchain technology to validate skills and to enable users to continue to master their data). The types of record saved on the blockchain were often transactions of currency, smart contracts and digital signatures and certificates (mostly saved as hashes).

4.2 Use of blockchain technology for education and employers

All blockchain-based education technologies demonstrated the advantages of blockchain technology that have been discussed in the literature. Most blockchain-based education technologies aimed to provide trust, followed by immutability. An example is Everipedia, which uses blockchain technology to democratize and decentralize an online encyclopaedia. Besides, during the assessment of the technologies, we added the categories efficiency (e.g., faster solutions through automatized reward systems) as well as equal opportunities and motivation (e.g., the use of cryptocurrencies (i.e., tokens) to motivate learners to participate), which were also often provided by the education technologies (i.e., equal opportunities were less common than efficiency and motivation). An example of a blockchain-based education technology that provides equal opportunities is an online, publicly editable, free encyclopaedia that disenables censorship by governments. Overall, the blockchain-based education technologies showed an average of 2.69 (*SD* = 1.11) advantages.

Most of the blockchain-based education technologies in our sample did not pursue the goal of individualizing education; only a small portion of the technologies made this their aim. However, it is important to recognize that most of the individualization of education is caused by the education technology (e.g., through live video chats) and not by the blockchain technology. For example, the micro-learning platform Code of Talent, which is blockchain-based, plans to provide a variety of different courses paired with interactions.

The needs of employers, however, can be addressed through blockchain-based education technologies in more than half of the cases. Employers can profit from the trust created through blockchain technology. In addition, the technology enabled them to find more suitable candidates and/or to find candidates more quickly.

4.3 Target group of blockchain-based education technologies

Most of the blockchain-based education technologies were made for the general public and therefore for learners who were not particularly associated with one institution (e. g., learning platforms with no particular target group) or for job seekers (e. g., connecting job seekers to employers).

Almost 30 % of the technologies did not have a second user giving input or profiting from the technology (e. g., when tutors and learners are connected through a learning platform, there is a second user; but there is no second user when a learner simply uses the platform to store his/her certificates). Among those technologies that did have a second user, most were used by employers, followed by teachers/instructors (e. g., a skill-sharing platform connecting knowledgeable instructors with learners).

Over 40 % of the blockchain-based education technologies did not have a direct learning function but rather had an administrative or supportive function. Of the technologies with a learning purpose, most were developed for higher education and/or adults in general.

5 Discussion

This study is the first to systematically analyse the use of blockchain technology in education. We assess the blockchain-based education technologies that are currently or will soon be available for innovation in education. Based on our analysis, we develop an agenda for future research.

We analysed 62 providers that apply blockchain technology in different ways for an educational purpose. The blockchain-based education technologies analysed here include some technologies that have a learning focus and others that perform administrative and supportive functions in education. In line with the previous literature, our content analysis reveals that blockchain-based education technologies offer many advantages for education. For example, they are efficient, have a motivational purpose and enable equal opportunities for learners. More than half of the technologies were useful for employers, but only some contribute to the individualization of education (i. e., mainly through additional functions of the education technology and not through the functionality of the blockchain technology). Current blockchain-based education technologies were primarily made for the general public and job seekers, and the ones with a learning function mainly target adult learners and higher education. However, these are only general tendencies, as the set of blockchain-based education technologies analysed here is quite diverse.

5.1 Contribution to answering the question of whether blockchain-based education technologies can disrupt education

We contribute to a highly relevant research topic by analysing how blockchain technology can be applied to education. Our results provide a deeper understanding of blockchain technology in education and serve as a signal to educational stakeholders by highlighting the importance of blockchain technology in education. Particularly, returning to the question of whether blockchain-based education technologies have the potential to disrupt education, we can conclude the following based on our results.

We find that a large portion of the education technologies serve a wider purpose than the underlying blockchain technology itself. This finding underlines the compatibility of blockchain technologies with current education technologies. Through its unique features, blockchain technology seems to have the capacity to improve education technologies. However, the fact that blockchain technologies are only used to individualize education in some cases also indicates that blockchain technology might need further development to contribute to the disruption of education. The results show that the types of records saved on blockchain technology are approximately equally distributed (except for documentary evidence of ownership rights), showing that all current possibilities for saving records on the blockchain are being used.

Blockchain-based education technologies seem particularly promising because they provide many advantages compared to traditional education. Among other advantages, blockchain technology serves as a disruptor of traditional education through its purpose of building trust between the involved parties. In addition, we found that blockchain-based education technologies aim to enhance efficiency and motivation as well as to provide equal opportunities for learners. This finding further underlines how useful blockchain technology can be to enable a movement towards digitalization and social equality. Most blockchain technologies offer several advantages, highlighting the important changes that blockchain-based education technologies can create.

It is not surprising that most blockchain-based education technologies did not pursue the goal of individualizing education, as the particular structure of blockchain-based education technologies enables the creation of democratic opportunities. Employers seem to profit from blockchain-based education technologies. Particularly, technologies that provide more transparency regarding learners' achievements – and therefore their skillsets – can enable trust between employers and potential candidates and help the employers to find suitable candidates.

The finding that most blockchain-based education technologies address a general public or job seekers demonstrates the capacity of blockchain technologies to improve learning opportunities for all groups of learners. However, this finding also shows that higher education institutions should not miss the chance to take advantage of blockchain-based education technologies, because they provide learning opportunities that go beyond those offered by traditional education.

In summary, considering the question of whether blockchain technology has the potential to disrupt education, we can conclude that blockchain-based education technologies already offer many approaches to possibly changing education and therefore have the potential to provide substantial educational innovations. However, this process of change is currently only in its infancy.

5.2 Conclusions about blockchain-based education technology and future research

In this paper, we found that blockchain technology can be applied to education and provides important advantages for education. We focused specifically on blockchain-based education technologies. However, our analysis does not allow conclusions about the actual use of blockchain-based education technologies in education. According to recent newspaper articles, press releases and blog posts, higher education institutions and employers have started working with blockchain technology or are currently developing ideas about how to employ blockchain technologies in education (i. e., to award and save student records and to verify students' academic achievements) (Skiba, 2017). Examples are the Media Lab Learning initiative of the Massachusetts Institute of Technology and Sony (Friedlmaier et al., 2017; Rooksby, 2017; Russell, 2017; Turkanović, Hölbl, Košič, Heričko, & Kamišalić, 2018). However, most of these initiatives are currently under development, and the application of blockchain technology to education is clearly still at an early stage. One reason for this modest use of blockchain-based education technologies is that, even though research on blockchain technology is booming, it is also still in its infancy. Similarly, the creation of blockchain-based business models is a recent but up-and-coming area. Therefore, educational institutions might not yet be aware of the available blockchain-based education technologies and may not yet have the blockchain-based education technologies they need (i. e., some of the assessed blockchain-based technologies were still in a beta phase). Another reason for the rather modest adoption of blockchain-based education technologies is that education is a very particular context. Education – and particularly educational institutions – react slowly to digitalization in general and are managed very traditionally. As a result, it is interesting to become aware of their needs when it comes to the introduction of blockchain-based education technologies.

In a similar vein, we analyse the advantages of blockchain-technology for higher education and provide important information on the characteristics of these technologies. Our analysis offers a provider-oriented view of the advantages of blockchain-based education technologies. However, the perspectives of other important stakeholders remain open. For example, the acceptance and demands of potential users of blockchain-based education technologies are highly important when it comes to the introduction of such technologies. This perspective is important in order not only to get a perspective on the users' needs but also to understand which difficulties might arise while introducing the use of blockchain-based education technologies.

However, blockchain technology itself also requires further development. For example, researchers are currently working on the following topics: (1) problems in scalability (Swan, 2015), (2) speed versus security trade-offs (Kiayias & Panagiotakos, 2015), (3) decreasing the currently high costs of operating blockchain technology (e. g., hardware) (Zambrano et al., 2017) and (4) decreasing the use of the vast amounts of energy consumed by blockchain technology (Zambrano et al., 2017). These aspects also affect the usability of blockchain technology in education. In particular, even though blockchain technology might provide advantages for developing countries, its infrastructure requirements are still very high and might therefore create obstacles for emerging economies to participate in blockchain-based education (Zambrano et al., 2017).

In this paper, we addressed blockchain-based education technologies, concentrating on technologies with a focus on education. However, one clear advantage of blockchain technology is that it might be able to connect several industries and aspects of everyday life. For example, in this paper, we assessed blockchain-based education technologies in the area of identity management when there was a connection to education. However, identity management in general can be applied to many areas of everyday life. We did not include blockchain-based technologies with a general focus that might still be applicable to education but do not focus specifically on education.

Previous research has already pointed to the assumption that the changes that occur in various business areas through blockchain technologies might be rather gradual than instantaneous and disruptive (Iansiti & Lakhani, 2017; Swan, 2015). Our results seem to confirm this point of view.

Our findings and literature analysis leave us with the following questions for future research: First, research should continue to consider new ways to apply blockchain technology to education. For example, smart contracts might be used to regulate achievements (Zambrano et al., 2017), and knowledge platforms such as Everipedia could be further developed in the direction of peer-to-peer learning platforms. Therefore, the possibilities that blockchain technology provides with regard to the democratization of education should be explored. Swan (2015) assumes that the application of blockchain in areas such as education will take extra time. Future research should promote the development of blockchain-based education technologies. Second, as described above, blockchain technology must be further developed before it can fulfil the needs of education. Information systems research is in a unique position to focus on precisely this type of development. Third, blockchain-based education technologies should be tested in the context of education. Future studies should assess how blockchain technology can be integrated into other education technologies. Fourth, studies should assess the perspectives of other stakeholders on the introduction of blockchain-based education technologies (e. g., the conditions under which users accept blockchain-based education technologies). Fifth, future research should determine which blockchain-based education technologies educational institutions need as well as the requirements that must be met if education is to include blockchain-based education technologies in teaching (i. e., with regard to both policies and technological needs). Sixth, future research should assess business models of blockchain-based education technologies. For example, we found that many blockchain-based education technologies use cryptocurrencies to raise money instead of using a process of venture capital acquisition; this choice might be an interesting aspect of these new business models. Seventh, in this paper, we focused on the positive consequences of using blockchain technology in education. However, there might also be negative consequences. For example, with regard to a learner's curriculum vitae, until now, one could omit certain work experiences from their application in order to highlight their specific suitability for a position. Such changes might not be possible if blockchain technology is used. Hence, future research should take a holistic approach and analyse positive as well as negative consequences of the use of blockchain technologies in education. Future research should rely on different data sources, such as surveys or interviews, to consider users' perspectives on blockchain technology. Similarly, as soon as blockchain-based education technologies become more commonly used in education, objective user data could be used as a basis for analysis, for example, in relation to performance data.

6 Conclusion

In conclusion, we assume that blockchain technology can induce change in education. However, we feel confident that this change is not yet complete. Blockchain technology is in a constant process of development, and future research should continue to harness the possibilities blockchain technologies offer for education.

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Article submitted: 28.12.2018
Article accepted: 21.05.2019

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Agile by technique – The role of technology enhanced learning in higher education

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The use of digital technology in higher education stresses the importance of agility which leads to a massive reshaping of teaching and learning for lecturers, learners, and the educational organization. The changed learning conditions are described by the term technology enhanced learning (TEL). Digital platforms and software that support learning and teaching processes such as massive open online courses (MOOCs), learning management systems (LMS), open educational resources (OER) enable higher agility to the institutional stakeholders (higher education institutions, lecturers and students) that are directly affected. The article aims to create a transparent overview of existing TEL platforms in higher education and their impact. The recent research will be collected in the form of a systematic literature review.
Furthermore, we show the impact on relevant user groups. With the increasing flexibility and availability of content, both groups, students, and teachers become more agile. TEL influences agility in terms of participation, continuous improvement, and faster processes and feedback.

1 Introduction

The digital transformation (DT) affects all areas of working life (Bender, 2016). The benefits of these technologies enable and require more agility at the same time (Bennett, Agostinho & Lockyer, 2015). Agility is defined as the ability to react quickly to sudden changes and to use these changes to gain an advantage (Sharifi & Zhang, 2001). Furthermore, agility is the ability to react efficiently and effectively to emerging opportunities through the use of existing information technology (IT) potentials (Neumann & Fink 2007). In this article, agility in the field of higher education is meant as the capability of *continuous improvement*, *rapid feedback* and *participation* needed to master today's study and life situations. The everyday life of students is increasingly determined by digital technologies (Gottburgsen & Wilige, 2018) which trigger the demand for increasing agility of user groups in higher education institutions. Many technical solutions are available which support the digital transformation and cause agility in higher education institutions, and those technologies are proven to exert decisive impact on teaching style (Bennett, Agostinho & Lockyer, 2015). The changed learning conditions are summarized under the term technology enhanced learning as an expression of the digitalization in the educational context (Kirkwood & Price, 2014). The main goal of this is to increase the quality of teaching and improve learning success simultaneously (Janson, Söllner, Bitzer & Leimeister, 2014). In research and practice, many impulses from various disciplines arise which have led to non-transparent results and missing access to adjacent fields of study (Henderson, Selwyn & Aston, 2017).

The article aims to create a transparent overview of existing technology enhanced learning (TEL) systems by concentrating on digital platforms where teaching and learning occur, rather than on single devices or teaching cases. Current research in the field of higher education institutions will be compiled and analysed regarding the directly affected target group, as well as the impact and interaction of the different systems. Moreover, the effect on agility concerning students and teachers will be determined. For this purpose, we offer a brief introduction to clarify the basic terms of agility and the digital transformation in higher education (chapter two). Following a systematic literature review approach (chapter three), we provide an overview about the dominating digital platforms that shape technology enhanced learning (chapter four) to answer the following research question: *What kind of TEL systems are used in higher education?* Further, we will examine their *impact on the stakeholders' agility* (chapter five). In this study, we focus on participants who benefit from these systems and the expected outcome. This article closes with a conclusion that will also provide limitations and a further outlook on future research.

2 Theoretical foundation

2.1 Agility in higher education

Agility in higher education, like the related terms of agile education or lean learning, is a relatively new concept (Parsons & MacCallum, 2019). In the organizational context, the term agility is already widely known and sufficiently defined. Accordingly, agility is a construct that contributes significantly to ensuring the long-term survival and success of a company (Felipe, Roldán & Leal-Rodríguez, 2016). In this field, agility is understood as the ability to react effectively and efficiently to changing environmental influences (Ashrafi et al., 2005). Furthermore, it has been shown that agility as a concept is particularly successful if a sufficient infrastructure of information technology is available. Here, IT is regarded as a decisive factor for the success of the implementation of agility concepts in companies (Park, Sawy & Fiss, 2017). To further subdivide the concept of agility, various subtypes of organizational agility were defined. According to Sambamurthy, Bharadwaj and Grover (2003), organizational agility is divided into three agility dimensions: customer agility, partnering agility, and operational agility. These three subtypes of agility were supplemented almost ten years later by cultural agility (Caligiuri, 2012). The structural changes in higher education through the introduction of agile methods, primarily affect the relationship between students and lecturers (Gottburgsen & Wilige, 2018). For this reason, it is logical to highlight the potential significance of the specialized agility dimension of customer agility for higher education. Customer agility describes the relationship between an organization and its customers regarding the development or/and continuous improvement of products and services (Sambamurthy et al., 2003). Customer agility, in particular, uses various technical tools that give customers the opportunity for *rapid feedback* and, thus, are considered to *participate* in the *continuous improvement* of products or services (Mukerjee, 2014). Accordingly, we define agility in this paper as the capability of *continuous improvement*, *rapid feedback,* and *participation.* Abundant indications have emerged that adopting the concept of agility is necessary for successfully adapting academic teaching to future conditions and challenges (Mukerjee, 2014). Many changes at the levels of technological development, international competition, and financing are helping to dismantle the long-established structures of universities and enrich them with more agility. This transformation is of utmost importance, regarding the changing working conditions, accompanied by specialized, high-tech professions (Gottburgsen & Wilige, 2018). Agility (enabled by technology use) leads to competitive advantage, which may foster success and long-term survival (Mukerjee, 2014). Teachers and students profit from agility that enables *fast reaction, continuous improvement,* and a higher degree of *participation*. In the following, we will give a brief overview of the technology-driven digital transformation of higher education institutions.

2.2 Digital transformation in higher education

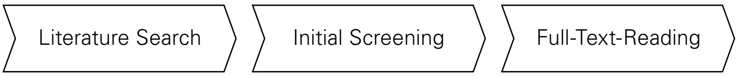
The term digital transformation describes the use of new digital technologies to enable major improvements (Fitzgerald, Kruschwitz, Bonnet & Welch, 2013). Consequently, teaching and learning are massively influenced by digital transformation (Gottburgsen & Wilige, 2018). New communication technologies offer many possibilities for overcoming constraints of entry and time barriers to learning. The so-called open university allows access even for non-traditional students (Zawacki-Richter, von Prümmer & Stöter, 2015). Within this context, the term technology-enhanced learning or synonymously technology mediated learning (Janson et al., 2014) is often used to describe computer supported learning. Still, explicit statements about what the term means or entails are scarce (Kirkwood & Price, 2014). At its core, TEL is a learning environment based on technology use and promises an improved learning or learning management. The term is *"describing the interface between digital technology and higher education teaching"* (Bayne, 2015). The relevant technologies support access to learning material, enable communication and collaboration, offer room for learning through construction, can be used for learners' assessments, and improve digital and multimedia literacy (Goodyear & Retalis, 2010). The term is closely linked to the German expression *Bildungstechnologien* such as learning management systems, Blogs, and Wikis, which distinguishes it from the devices used (Nistor, 2018).

The first stream of research about TEL concentrated on the devices that could be implemented (Gikas & Grant, 2013). Mobile devices, such as smartphones or tablet computers, may support student learning and can be used to participate in traditional (face-to-face), blended learning classes, or pure e-lectures (Rodríguez-Triana et al., 2017). In times of *bring your own device*, recent research often concentrates on the virtual assets (Fischer, Heise, Heinz, Moebius & Koehler, 2015). The term has migrated from the handling of a technical product to the application of the digital resources provided in the foreground. We follow this approach and summarize technology enhanced learning as the digital platforms that make learning possible. We will not examine individual technologies, devices, or applications, such as teaching cases, in detail in this article. Rather, these characteristics are to be viewed as a subgroup of the platforms and are therefore over-specified. Via platforms and software such as massive open online courses (MOOCs) (Burd, Smith & Reisman, 2015), learning management systems (LMS) (Abdel-Maksoud, 2018), and open educational resources (OER) (Bennett et al., 2015) recent learning material can be provided. Furthermore, the relevance of wikis, forums, or other social media systems is increasing, and this eases the communication between the participants (Tess, 2013). The use of the systems leads to four different goals: to motivate people, to enrich learning resources, to implement learning and instructional strategies, and to assess and evaluate learning goals (Wang & Kinuthia, 2004). The influence of TEL in higher education institutions, though often examined, is still not yet described in detail. Many research findings deal with the implications for students (Gikas & Grant, 2013; Henderson et al., 2017) and their learning success (Janson et al., 2014). However, only minimal research focused on the teachers is available (Unal & Unal, 2017) and the institutional impacts are rarely addressed in the research (Schweighofer, Weitlaner, Ebner & Rothe, 2019). Thus this paper concentrates on the impact of TEL on this directly-affected stakeholder group. In the long term, the influence on cultural values and pedagogical issues may come to light. To draw a picture of the transformation, we provide an overview of the current research dealing with the different applications available in higher education and will begin by describing our research method.

3 Method

The base of our work is a literature review which provides an overview of synthesis of the recent trends and gaps related to the aforementioned scope (vom Brocke et al., 2015). We follow a systematic approach to identify, structure, and synthesize the relevant literature (Schryen, 2015). Therefore, our approach provides the methodological benefits of high replicability due to a transparent approach and traceability. In the following section, we provide the most up-to-date definitions of terms, including dominant research trends (chapter four). This groundwork provides a context to analyse the influence on directly affected stakeholders in chapter five. Figure 1 shows the research process.

Figure: The Research Process



As the first step for our study, we identified a term-defined database for further analysis. To develop the search terms for our review, we firstly scanned and read articles from the field of interest. Since agility is a very new term in relation to higher education and has not yet been very sharpened in the literature (Parsons & MacCallum, 2019), we have excluded this term in the first step of the search because it would reduce the search field inordinately. Through a literature research, we deduced a set of relevant buzzwords. We combined the term *higher education* with recent technologies (see table 1). Using the TEL definition, and a scope that included terms used in both English and German, we deliberately decided to use only digital platforms and software solutions, thereby excluding buzzwords such as flipped classroom. We searched through relevant journals using the database ERIC as it contains most of the journals named by the *Verband für Hochschullehrer* in the specified field. Furthermore, we explored pertinent journals like the *Beiträge für Hochschulforschung*, and chose only to consider peer-reviewed journal articles. The search was conducted from February to March 2019, and due to the amount of material, we decided to limit the searching period to the last five years, as we have focused on recent research outcomes and new developments for TEL in higher education. As a second step, we performed an initial screening, whereby the abstracts of the identified articles were scrutinized to ensure they fulfilled the criterion of relevance. We regarded a paper as relevant if it dealt with the use and application of the technologies in higher education, along agility characteristics, as mentioned in chapter 2.1. Articles describing the consequences of technologies and implications for learners and teachers (Tikkamäki & Mavengere, 2013) were also considered pertinent. However, we dismissed papers that were not directly related to the topic. As the last step, we performed full-text analysis of the remaining papers to gather information about recent research in the fields named herein. We collected and analysed examples of technology use and usage scenarios. Furthermore, we read the papers critically, focusing on characteristics that enable agility within the context as well as characteristics of enhanced learning and the impact on the students. All in all, we identified 330 sources in step one and limited the number in step two to 249 relevant articles. Table 1 presents the results of our literature research:

Table: Results of our literature research

Search Strings	Step 1	Step 2
"OER" OR "Open Educational Resources"	66*	42
"MOOCs" OR "massive open online courses"	175*	132
"Study Assistant" OR "Studienassistenzsystem"	7 **	0
"learning management" OR "course management system" OR "LMS" OR "Lernmangement")	82*	75

* Restrictions: Peer-reviewed only, since 2015, Descriptor: Higher Education.
** Restrictions: Peer-reviewed only, since 2015.

For OER, we dismissed articles without a clear focus on learning (like open research platforms or open production), and it quickly became apparent that there is a great research interest in massive open online courses, which is reflected in a large number of publications found. In the second step, we identified 132 of 175 sources as relevant to the field of investigation. For the learning management system, we identified 82 sources. After an in-depth reading of the texts, we dismissed seven articles, as they did not seem relevant for the field or proved tangential and therefore unspecific (e. g. research about data literacy). Despite the fact that the literature research produced only a few sources on the topic of a digital study assistant (see table 1), the term nevertheless will be introduced as a subcategory of the LMS. The findings presented here will be elaborated in the next chapter and enriched by further descriptions of characteristics. In the following section, we will describe the fields of research for each major technology category and show actual trends and essential findings for the last five years. Also, important definitions of terms are given, and historical developments from current sources are included.

4 Results

4.1 Open educational resources

The growing agility in higher education is mainly explained by the use and support of digital educational resources, such as open educational resources (OER) and other technologies which have a decisive impact on the type of teaching (Bennett et al., 2015). UNESCO defines OER as resources for teaching, learning, and research in any medium. One important characteristic is the free access and use, adaptation, and redistribution by others without or with minor restrictions (Butcher, Malina & Neumann, 2013). The origin of the OER movement dates back to 2001 and is based on the OpenCourseWare initiative of MIT (Kopp, Gröblinger & Zimmermann, 2017). MIT's goal was to make all the learning materials used by their 1800 courses available via the Internet, where the resources could be used and repurposed as desired by others, without charge (Weller, 2014). "*This concept must be perceived as innovative because it describes a general economic and social paradigm shift: Education, which formerly* *was limited to a specific group of learners, now, is promoted as a public good.*" (Richter & Veith, 2014, p. 205). Since then, the use of OERs has steadily increased, and in relation to that, the Creative Commons states in 2017 that nearly 1.5 billion OER objects were licensed ("A Transformative Year," 2018). In Fact, the European Commission has funded several OER related projects, like *Open Science Resources*, *OrganicEdunet*, *Ariadne* and many more which dealt with the collection, production presentation, quality, and management of OERs and focused on improving education. This research highlighted two journals which predominantly deal with OER-related themes (*Open Praxis* with nine articles and *The International Review of Research in Open and Distributed Learning* with 19 publications). Beside case descriptions (Kaatrakoski, Littlejohn & Hood, 2017) and examinations of perceptions (Hilton, 2016), some authors search for business models of OERs (Wang & Wang, 2017) or describe country-specific applications (Shigeta et al., 2017). Despite the advantages, only a small number of universities have turned to an open resource approach in education (Doan, 2017). This finding reveals a clear research gap in the form of the following research question: Why is the adoption of OERs still limited and why have many universities not joined this trend yet?

4.2 Massive open online courses

Massive open online courses represent an important element within TEL systems (Yousef, Chatti, Schroeder & Wosnitza, 2015). The interest in MOOCs has risen strongly in recent years, and it is therefore not surprising that the number of professional publications focused on it has increased enormously (Zawacki-Richter, Bozkurt, Alturki & Aldraiweesh, 2018). MOOCs were launched in 2008 by Siemens and Downes when they opened a course at the University of Manitoba for an original number of 25 university students worldwide but ended up with over 2000 people enrolled (Mohamed & Hammond, 2018). However, it was Dave Cormier who characterized the term MOOC to describe this kind of course (Mohamed & Hammond, 2018). The name already contains the definition, since this is essentially a large, open online course. Massive means that the course can theoretically be used by a very large number of learners (Armellini, 2016), while the word open refers to the openness or usability of the course without further restrictions. Despite being conceived as purely online courses, MOOCs, in practice, are often held in classroom settings (Blackmon & Major, 2017). This does not necessarily imply a fixed start and end time, but refers to a specific topic and provides meaningful organization of the individual topics (Blackmon, 2016; Blackmon & Major, 2017). MOOCs can differ greatly in size and degree of openness (Lowenthal & Hodges, 2015). A common subdivision of MOOCs is the pedagogical distinction between connectivist MOOCs (cMOOCs) and extended MOOCs (xMOOCs) (Mohamed & Hammond, 2018). The trend is heading towards a more distinct classification like synchMOOCs, asynchMOOCs, or madeMOOCs (Blackmon, 2016; Blackmon & Major, 2017). This broad differentiation accounts for the countercurrent against a one-size-fits-all model of the past as postulated by LeBlanc (2018) and thus addresses the respective differences in circumstances, like disparate and varied course content and learning goals. The hopes assigned to MOOCs in the future particularly lie in improving education in countries with low educational opportunities (Blackmon, 2016). It can be observed that MOOCs are moving towards certification of their courses although they are still primarily independent of payment (Blackmon & Major, 2017; Shigeta et al., 2017). Moreover, the initial euphoria seems to have already subsided, giving way to a realistic assessment of the performance of MOOCs in terms of, for example, access to higher education (Baker & Passmore, 2016; Fischer et al., 2015). Here, research should focus on harnessing the great potential of MOOCs for free access to education and training (Alzahrani, 2018).

4.3 Learning management systems

Learning management systems are online learning environments or platforms with functionalities for flexible and active learning (Cabero-Almenara, Arancibia & Del Prete, 2019). They are used to publish materials, upload course syllabi, deliver notes, request and collect student works, etc. The term course management system (CMS) is used synonymously (Management Association, 2018). In practice, several different platform systems are used, such as Stud.IP, Blackboard, Canvas, e-College, Moodle, and Sakai (Borboa, Joseph, Spake & Yazdanparast, 2017). Additionally, many social media activities, like wikis, chat, and assessments can be integrated within the LMS (Son, Kim, Na & Baik, 2016). The majority of articles was published in *Education and Information Technologies,* followed by the *International Review of Research in Open and Distributed Learning.* Several researchers focus on perceptions of the students (Borboa, 2017) and teachers (Basal, 2015) using an LMS. In some studies, the role of faculties is examined (Rhode, Richter, Gowen, Miller & Wills, 2017), while others focus on reasons for use (Abdel-Maksoud, 2018). Because just about every action in an LMS can be observed and stored, insights based on this data can be gained for the purposes of learning analytics (Kuhnel, Seiler, Honal & Ifenthaler, 2018). The knowledge about the student's behaviour can be used to adjust learning and teaching methods (Joo, Kim & Kim, 2016). Further research in this field deals with the use of specific platforms for didactic purposes (Cabero-Almenara et al., 2019), and researchers consistently examine ways to raise interaction (Holmes & Prieto-Rodriguez, 2018). This could explain why one of the largest research streams in e-learning is taking up a currently dynamic sub-topic of LMS: gamification (Chen, Huang, Gribbins & Swan, 2018). A study assistance system is an instrument of electronic study information, monitoring, and control that can also be used for further training courses. With appropriate expansion and differentiation (e.g. by creating interfaces) it can enhance the LMS. Besides the information from the LMS, students get information about their assignment related to the European credit transfer system (ECTS), as well as their level of achievement within the framework of the curriculum. At the same time, information on the progress of studies are available, which can also be related to certain institutions, study programs, modules, or module connections. In this way, undesirable individual developments of students or even of institutions can be identified quickly.

5 Discussion

5.1 Implications for higher education institutions

Although the direct stakeholders of the technology enhanced learning environments are students and lecturers, the higher education institution (HEI) as a major arena of learning plays a crucial role. It is the task of the institutions to integrate the systems and to ensure their smooth interaction (Fischer et al., 2015; Kirkwood & Price, 2016). HEI expect success and long-term survival by becoming agile and enabling agile processes (Twidale & Nichols, 2013). The digital transformation fosters agile structures in this field (Mukerjee, 2014) and moreover knowledge transfer is a core process in this context. Directing a process towards agility by using technology enhanced learning prepares participating institutions for the future. Further market models may arise (Baker& Passmore, 2016; Gordon, 2014), thereby providing more content with a higher range of coverage (Burd, Smith & Reisman, 2015). Still, research in this field is siloed and mainly concentrates on single technologies. We identified only a few articles that tackle more than one of our examined technologies (Kopp, Gröblinger & Zimmermann, 2017; Shigeta et al., 2017). Thus we conclude that an overview of existing systems and their interplay is still missing. Some authors provide lists of tools and applications (Fischer et al., 2015;), but the interplay seems to be rarely examined (Kirkwood & Price, 2016). OER provide access to online courses that are available for large groups such as MOOCs. LMS can help to control the composition of these courses and provide central access to the relevant materials. Communication within the courses can also be handled via the social media functionalities of the LMS, and study assistants can collect data and compress it into so-called study dashboards. On the basis of those data made available within the course platform, learning analytics systems evaluate the students' performance. Still, higher education institutions struggle with the integration of TEL systems. They require clear guidelines for adoption and technological integration (Feldman-Maggor, Rom & Tuvi-Arad, 2016). Researchers claim that providing institutions with tools and devices is insufficient, and some opine that general standards for the quality of content and data security among OERs and MOOCs are still missing (Ochoa & Ternier, 2017). Furthermore, we miss the consideration of the strategic impact of TEL; for example, digital transformation is known to have a significant influence on the strategies of enterprises (Hess, Matt, Benlian & Wiesböck, 2016). It stands to reason that the same should be true for higher education institutions.

5.2 Impact on students' outcomes

The majority of today's students is labeled as the generation of the so-called "digital natives". For them, who are raised with new technologies, the classic style of teaching is often seen as a contrast to their normal lives, which in many cases leads to deep conflicts (Loeckx, 2016). The introduction of TEL systems in higher education can have positive impacts on everyday learning and affect them in different ways (Kirkwood & Price, 2014). Cognitive, reflective, analytical, synthetic, dialogical, technical, and socio-cultural benefits for participants using TEL have been proven (Al-Khatib, 2011). *Participation:* In this context, the targeted use of OERs also makes sense to consider the individual interests and learning types within the heterogeneous body of students. It has already been postulated that one of the greatest challenges of the next ten years is to transform the current study system which is like a one-size-fits-all model to a free system which can be highly customized to the needs of students (LeBlanc, 2018). *Continuous improvement*: Changes in the heterogeneity of learners include socio-cultural and educational backgrounds. Here, MOOCs are an obvious choice with which learners are no longer bound to these components, but can nevertheless pursue their study goals (Rohs & Ganz, 2015). Also, digital study assistance systems can help students to adjust their combination of modules and lectures to be personally manageable. For example, they enable individual planning of semesters or modules and can provide important information for students wishing to choose an individual way of studying. Initial approaches of this kind of a digital study assistance system already exist (SID-DATA, 2019). Students seem to have a positive perception of their ability to use new learning technologies (Nami & Vaezi, 2018). Also, there is another benefit, especially for OERs, as it has been proven that they have a positive impact on the perception and attitude of students towards learning. Furthermore, there is no evidence shown that OERs have a negative impact on students' performance (Weller, De los Arcos, Farrow, Pitt & McAndrew, 2015). In addition, research has pointed out that the intention of students to use MOOCs in an academic context is raised by the perceived ease of use and in their attitude positive towards them (Tahiru & Kamalludeen, 2018). For the most part, students would like to use more technologies for efficient and convenient access to content and are eager to use these for academic purposes (Mirriahi & Alonzo, 2015). The learning management system has also shown higher performance impacts for lecturers and learners than traditional face-to-face classroom settings (Bere, Deng & Tay, 2018) which underlines the increment of learners' success by using TEL.

5.3 Impact on lecturers

Participation: One of the main motivations to use a MOOC from a teacher's perspective can be categorized as altruistic (Lowenthal, Snelson & Perkins, 2018). An example, in this case, is the desire to deliver academic content in areas where students have no or little access to such content (Blackmon, 2018). By providing content to a large group of students, the level of awareness increases. In a competitive academic world, this may lead to advantages for the lecturers, as their expertise can be leveraged (Blackmon, 2018). *Rapid feedback:* Furthermore, the use of TEL enhances the feedback possibilities, e.g., via LMS (Basal, 2015), as learners are enabled to react rapidly (Bennett, Agostinho & Lockyer, 2015). The direct responses may lead to commonly improved design and content (Bonafini, 2017). These data are also important for formative evaluations and assessments (Riedel & Möbius, 2018). The construction of MOOCs makes professors reflect on their teaching because they receive feedback from forums (Loeckx, 2016). Another motive named in the literature was the opportunity to experiment with new technologies (Blackmon, 2018), which may lead to higher intrinsic motivation and increased capabilities of the lecturers (Buhl, Andreasen & Pushpanadham, 2018). Furthermore, the lecturers profit from more flexible working conditions (Gordon, 2014). C*ontinuous improvement:* The role of teachers changes from a knowledge-transmitter to a learning-coach (Loeckx, 2016). The ubiquitous availability of content must lead to the *continuous improvement* of the lectures to differentiate them from the masses. Despite the obvious value of technology-enhanced learning, there are also some negative points to mention. Teachers perceive disadvantages, especially of MOOCs, as compared to face-to-face courses regarding the individualized assessment and the group size (Lowenthal et al., 2018). Still, homogenous training to provide adequate professional development, to support teachers and to increase their awareness of the complex interaction between technology, pedagogy and cognitive content in their different disciplines is missing (Cabero-Almenara et al., 2019). Researchers have also proven the correlation between perceived ease of use and perceptions of usefulness of LMS (Wichadee, 2015). A standardized proceeding for TEL integration could help to assure a level of quality (Kirkwood & Price, 2016; Weller et al., 2015). The same applies to standards regarding the quality of the content of MOOCs and OER (Richter & Veith, 2014).

6 Conclusion

In this article, we examined recent research about TEL systems. Our findings present a broad picture of the digital platform capabilities and their role among HEIs. Our work contributes to practitioners as we detected recent trends in that field and describe the interaction of the systems and the implications for the stakeholders. We also see some contribution for researchers as we neatly described the actual state of the art. Our research shows: several systems with different goals do exist. As most systems seem to improve the learning and the learning outcomes, a tuned interaction may lead to further improvements for the stakeholders as well as for the HEI. TEL systems support agility in the way of fast feedback, participation, and continuous improvement. Agile processes are not limited to one stakeholder group; rather, all groups can mutually foster agility. Students *participate* in the design and improvement of study units through technical tools. *Rapid feedback* improves the lectures which can be enabled by technologies, such as online forums. In return, students receive much faster feedback on their achievements and questions, either from the systems or directly from the lecturers. *Continuous improvement* is the aspired result of the feedback processes. In this context, the targeted use of OERs also makes sense when considering individual interests and learning types within the heterogeneous body of students. Our literature research detected most findings in the field of MOOCs which may lead to the assumption that the field is the most demanding. As we detected only a few findings regarding study assistance systems, we assume, that this field has further need for research focusing on enhancements like chatbots or conversation agents (Hobert & Meyer von Wolff, 2019), dashboards for learning analytics (Kuhnel et al., 2018) and data security (Zimmermann, Lackner & Ebner, 2016). Despite our careful review and synthesis, the work is not without limitations. We concentrated on the platforms and systems, and we did not pursue usability, which would be part of "device research". Moreover, stakeholders beyond the directly affected target group, such as politicians, are an interesting topic for further research but did not fall within the scope of this study. Furthermore, we described the research process as detailed as possible to assure the traceability of the process and findings. Although we carefully prepared our literature research, researchers choosing different limitations and databases may come to divergent conclusions.

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Article submitted: 15.03.2019
Article accepted: 29.05.2019

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Blockchain diplomas: Using smart contracts to secure academic credentials

Fabian Schär, Fabian Mösli

In this article we describe how blockchain technology can be used to secure academic credentials. We provide insights from a joint project between the University of Basel's Center for Innovative Finance and BlockFactory Ltd, and show some considerations that went into the concepts as well as an evaluation on how these blockchain diplomas perform in comparison with other diploma solutions.

1 Introduction

Fraud is a serious problem in academia. A simple Google search for «buy fake university degree» leads to millions of results. Some of the service providers promise to deliver fraudulent diplomas within 24 hours and prominently advertise the fact that they have been in business for over a decade. Anyone can easily buy forged credentials for as little as USD 100. Needless to say, these fake diplomas have the potential to significantly damage the credibility of institutions and higher education as a whole.

Diplomas are generally used as a signaling mechanism, i.e. to demonstrate the presence of certain abilities. This signaling mechanism becomes much less efficient when it gets harder and more costly to distinguish between legitimate and fraudulent credentials. It is safe to say that this is the case with physical diplomas. These documents are simply not secure. Even with additional security measures such as holograms or watermarks, it is possible to counterfeit these documents. What makes things even worse is the fact that most application documents are either being sent in electronic form or using photocopies that obfuscate the security measures and mostly render them useless. Anyone familiar with basic software tools can easily modify sensitive data on these documents, including grades and even the name of the graduate. As a result, potential employers have to check back with the university to verify if the diplomas they have received are real. This supposedly simple request kicks off a highly bureaucratic process and results in a significant administrative burden for the universities. Moreover, the person processing the request faces the challenge of providing reliable information while making sure to be compliant with data protection law.

Some universities try to tackle this problem by using a centralized database and an online form to automate requests. While this certainly is a step in the right direction and significantly improves the efficiency, there are still certain drawbacks to this approach. In particular, a centralized database is a central point of failure. If someone succeeds in gaining access, this person could add new entries and edit or delete existing ones at his or her own discretion. Additionally, the diplomas' validity would be dependent on centralized infrastructure, meaning that diplomas could only be verified when the institution's database is available. If the database were to fail or if the institution were to disappear, the diplomas could no longer be verified and would therefore lose their usefulness. Outsourcing the responsibility by using a centralized database which is managed by a third party does not solve any of the afore-mentioned problems. On the contrary, it introduces additional dependencies and a severe lock-in. Ideally, there would be a shared database, managed by a large community, with everyone being able to autonomously verify the legitimacy of its records. That is exactly what blockchain technology can be used for and the starting point for our project (Grech & Camilleri, 2017; Jirgensons & Kapenieks, 2018).

This article is structured in four sections. After this short introduction (section 1) we proceed with section 2, where we provide an overview of the implementation. In section 3 we compare blockchain diplomas to other solutions and show where the advantages and disadvantages lie. In the fourth and final section we conclude.

2 Implementation

In early 2018 the University of Basel's Center for Innovative Finance partnered up with the Proxeus foundation and BlockFactory Ltd to secure course certificates on a public blockchain (Center for Innovative Finance (University of Basel) and Proxeus, 2018). We decided to use Ethereum[1] (Wood, 2014) Mainnet (the second largest public blockchain; Buterin et al., 2013). Ethereum allows small applications (smart contracts; Szabo, 1997) to be stored and executed in the blockchain network. In very simple terms, we add information on academic credentials to the Ethereum blockchain. Since it is a public database, anyone can easily look up the information and thereby verify if a specific diploma is part of the database. While using a permissioned ledger (e.g. run by a consortium of institutions) would also have been an option, using a public blockchain frees the participating institutions from the need to operate and maintain the respective infrastructure and services. Permissioned ledgers may offer better efficiency at the expense of superior immutability of a public blockchain – a trade-off we preferred to avoid (Zheng et al., 2017).

[1] There are other universities and organizations who have launched similar projects (University of Nicosia, 2019; MIT, 2019; Government Technology Agency (Singapore), 2019).

A simplified step-by-step model of the diploma registration process can be described in four steps:

(1) The university issues a pdf diploma. These diplomas look just like normal diplomas. Among other things, they contain the full name, student ID and the grade.

(2) The university computes a digital fingerprint *h* for each diploma file. The digital fingerprint is a 256-bit representation of the diploma.

(3) The university creates and relays a transaction containing *h*, with the goal to add *h* to the blockchain.

(4) The transaction becomes part of a valid block and is confirmed on the blockchain. As a result, *h* has become part of the blockchain.

The verification process works in a very similar way. Anyone who has received the diploma can recompute its digital fingerprint and compare the result to the values on the blockchain. If the value can be found on-chain and certain criteria are met, it serves as proof that the diploma is valid.

What is great about this process is that anyone can independently verify diplomas within a few seconds. There is no need for centralized infrastructure. However, the fact that anyone can join the network, look up values and even add new entries to the blockchain, raises some questions mainly about the documents' authenticity and data protection. The next few subsections describe how we have dealt with these issues.

2.1 Authenticity

In a public blockchain there is no central authority with special privileges or permissions. Anyone can join the network and issue new transactions. Transaction data eventually become part of the blockchain, meaning that anyone can add arbitrary information to the public database. It would therefore be a fallacy to assume that something must be true just because it is stored on a blockchain. In particular, an attacker could create a fraudulent diploma and add the digital fingerprint of this diploma to the blockchain.[2]

To ensure that only the university can manage its academic credentials, we use public key cryptography. To understand the concept, we need to provide some background information. Public key cryptography uses pairs of keys, that is a public key and a private key. Each individual (or institution) may autonomously pick a private key, i. e. a random number from an unimaginably large set, and use it to derive a correspond-

[2] For an introduction to blockchain see Berentsen & Schär, 2017; Berentsen & Schär, 2018.

ing public key (point on elliptic curve). While it is straightforward to derive the public key from a private key, it is computationally infeasible to invert the function and derive a private key from a public key. This is important since the private key serves a similar role as a password and must therefore remain secret at all times. The public key can be best compared with a user name. It serves as the individual's pseudonym in the network and can be disclosed freely. Thanks to the one-way characteristics of the derivation, the individual who has created the key pair remains in exclusive possession of the private key; despite having disclosed the public key.

The two keys have a mathematical relation that allows messages that have been encrypted with the private key to be decrypted with the corresponding public key (and vice versa). This property can be used as follows: Whenever an individual creates a transaction, this transaction message must be encrypted (signed) with the individual's private key. Since everyone is in possession of the corresponding public key, they will be able to decrypt the message with ease, and thereby receive proof, that the transaction has been issued by the individual behind the pseudonym. If the public key of the university is known, it can be easily verified if a specific diploma has been added by this university or by a third party.

2.2 Data protection

Academic credentials consist of personal data. We therefore have two conflicting goals. On the one hand, we want the information to be accessible and verifiable. When someone receives a diploma, this individual should be able to consult the blockchain and autonomously verify if the university has added these data to the public ledger. On the other hand, we do not want personal information to be publicly disclosed. Writing sensitive information, including full name, student id and grades on a public database, surely would not be a good idea nor would it be compliant with data protection law.

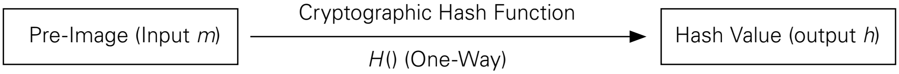
To circumvent this problem, we decided not to add any clear text information to the blockchain. Instead, we employ a special mathematical function and only store a cryptographic representation of the diploma on-chain, the digital fingerprint of the file. This so-called cryptographic hash function $H()$ is a deterministic one-way function that maps input data m of arbitrary length (pre-image), to a fixed-length output (hash value) $h = H(m)$. In our case, m corresponds to the diploma file and h therefore is the hash value of the diploma.[3]

[3] Computers represent everything as numbers. It is therefore possible to compute a hash value of text snippets or entire documents such as a diploma.

The term deterministic means that, given the same input, the hash function will always lead to the same hash value. In other words, there is no randomness involved. It is, however, important to point out that the results appear to be random, since even the slightest changes in the input lead to a completely different hash value. It is therefore not possible to deliberately generate hash values with certain characteristics, by picking the inputs.[4]

The term one-way means that it is infeasible to invert, i. e. it is straightforward to compute the hash value from the input but not the other way around. In other words, given *h*, it is infeasible to compute *m*. This relationship is shown in figure 1.

Figure 1: Cryptographic hash functions are one-way functions.



Now let us assume without the loss of generality that a university has issued one diploma. It uses a cryptographic hash function to compute the hash value of this diploma and then adds the hash value to the blockchain. Let us further assume that there are two types of observers: *A* and *B*. Observer *A* is in possession of the diploma and therefore is able to recompute the hash value and validate if it matches the hash value stored on-chain. Observer *B* is not in possession of the diploma. All he sees is the hash value that does not disclose any information on the original document.

The special properties of the hash function therefore allow anyone who is in possession of the diploma to verify if it is authentic. Those who are not in possession of the diploma will not gather any information from the hash value.

2.3 Smart contract

What we have described so far could be implemented without the need for a smart contract. As an example, one could use Bitcoin's Null Data (OP_RETURN) transaction type to achieve similar results. The hash values would be observable on-chain and,

[4] The function is non-injective, meaning that multiple elements of its input domain may be mapped to the same element of the output domain. In particular, since the input domain contains more elements than the output domain, we know that there must be collisions. However, due to the unbelievably large set of potential output values and the unpredictable effects when the input gets changed, it is infeasible to find any of these collisions.

thanks to the signature, one could also verify the source of the data. This very simplistic implementation would be sufficient, although somewhat cumbersome to work with. Moreover, this simple implementation would significantly limit our options.

For these reasons, we have decided to base our solution on a smart contract. A smart contract is a blockchain-based application that is governed by code and consists of a collection of state variables and functions. Its functions can be called by transactions. When called, they are executed in accordance with the contract's code and may change the state of the contract's state variables. We can use this contract to manage hash values of academic credentials.

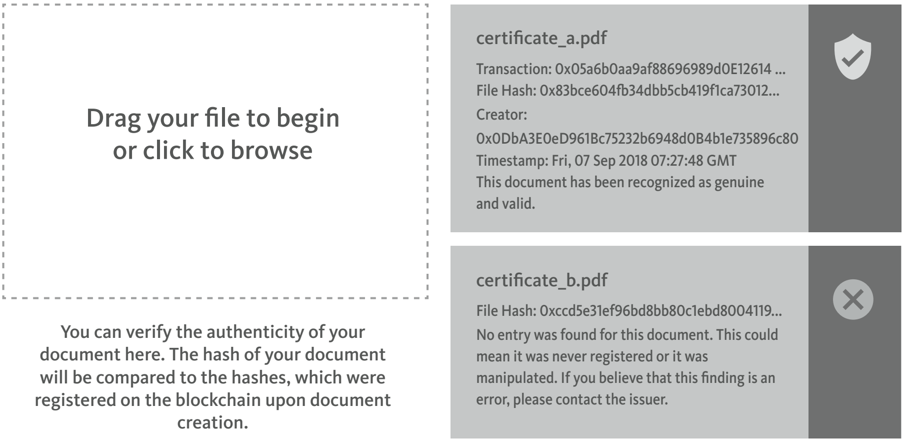
The main function of the contract allows new hash values to be added to the contract's storage. The contract accepts this addition only if the initiating transaction has been signed with the private key of a pseudonym that is associated with the university. Similar functions allow for the revocation of existing hash values and the assignment or removal of university representatives.

2.4 Verification tool

In theory, anyone can autonomously verify a diploma in his or her possession. The verifier has to install an Ethereum software client (e.g. geth) and thereby create a full node. He then has to download a copy of the entire blockchain and verify all transactions and blocks, compute the hash value of the document and compare the hash value to the ones stored in the smart contract. While it is great to have the option to verify the authenticity of academic credentials in a completely trustless environment and with no need to rely on anyone else, it is rather unlikely that, for example, an average human resource department will go through this process.

Well aware of this, we decided to provide a simple verification tool. The tool can be embedded in the university's website and is connected to an Ethereum node, such that anyone who receives a diploma can simply drag and drop the pdf on designated area to trigger a verification process. After a few seconds, the verification tool will show one of the messages shown in Figure 2.

Figure 2: Verification tool.



3 Comparison

Blockchain diplomas are just one among many solutions to secure academic credentials. Physical diplomas, certified electronic documents and similar projects implemented on a centralized database are some of the other options available. Accordingly, it is interesting to see how blockchain diplomas rank against these options and what advantages and disadvantages the solution has. The results are summarized in table 1 and discussed in the following subsections.

Table 1: High-level comparison between some of the available diploma options.

	Verification	Revocability	Timestamp	Cost Predict.
Physical Diploma	weak	no	none	fixed
Certified PDF	centralized	no	weak	fixed
Centralized Database	centralized	yes	weak	fixed
Blockchain Diploma	autonomous	yes	secure	variable

3.1 Verifiability

Academic credentials are only useful if they can be verified. We differentiate between autonomous and centralized verification. We call a verification process autonomous if someone who is in possession of the diploma can autonomously verify the authenticity of this document without having to rely on centralized infrastructure. We call a verification process centralized if the verification can only be conducted with the help of a central party (phone call, API call, web form or similar).

Blockchain diplomas are autonomously verifiable. The information is on a public blockchain, meaning that the process would work even if the issuing institution is no longer available.

The verification of diplomas based on centralized databases or certified PDFs rely heavily on centralized infrastructure. The same is true for physical diplomas. The process to verify these diplomas is usually not well designed, resulting in uncoordinated phone and email requests. Needless to say, these requests also depend on the existence of centralized infrastructure.

3.2 Revocation

Under certain circumstances institutions must be able to revoke academic credentials. If, for example, an irregularity is detected after a certificate has been issued, the issuer must be capable of declaring the document invalid. This can be easily achieved through an additional function in our smart contract that marks the respective diploma as revoked. Similar results are possible with a centralized database.

Physical diplomas struggle in this category. Once a physical diploma has been circulated, it must be assumed that numerous copies of this document exist. Without a database (blockchain or centralized) on which the status of the document can be updated, these copies are considered valid even if the original has been destroyed.

Certified PDFs can theoretically be revoked. However, in most cases it requires the issuer to invalidate the institution's certificate and therefore all academic credentials that have been issued with the same certificate.

3.3 Secure timestamping

A public blockchain can provide secure timestamps for any data. We can use these timestamps as an additional security measure to prevent backdating. If, for example, an institution's private key is leaked, a potential attacker would still not be able to issue diplomas from last year's class. We could add an additional criterion, i. e. define a specific time period during which the diploma has to be issued to be considered valid. If the diploma is issued during a different time period, it is considered invalid despite a potentially valid signature.

This is a big advantage over systems based on physical diplomas, which can be backdated indefinitely. In fact, it would be a rather straightforward task to recreate a diploma from 1975 with a different name. Even with certified PDFs and centralized databases one is at risk of backdating. If the certificate or the centralized database gets compromised, a potential attacker may theoretically be able to perform any changes.

3.4 Cost predictability

The main disadvantage of our implementation is that the costs are not as predictable as with the other options. Transactions on the Ethereum Blockchain are subject to a fee. The fee is determined by the market, i. e. whenever there is a large queue of pending transactions, fees may rise. Failing to match current market prices may cause the transactions to get stuck for several hours or even days. While diploma issuance is usually not that time critical, this is certainly a category in which blockchain diplomas perform worse than some of the other options.

If the transaction fees rise to levels that are not sustainable for this application, we could combine several hash values in a so-called Merkle root or include all individual hash values of a semester in a master document and only add the hash value of the master document to the blockchain (University of Nicosia, 2019). Both approaches have the advantage that they would only require one blockchain transaction, at the cost that an individual would require additional information besides the diploma itself to be able to verify the diploma's authenticity.

There is some hope that Ethereum's scaling solutions (EthHub, 2019) will solve this problem before it even arises. However, we must be aware that the project is, at least to some extent, dependent on a timely arrival of these solutions.

4 Conclusion

We are content with the progress of the project so far and see blockchain diplomas as a valid option for issuers of academic credentials. The main arguments in favor of blockchain diplomas are the secure timestamping as well as the autonomous verification. The somewhat unpredictable costs are a disadvantage compared to other solutions, however, there are alternative blockchain-based implementations that would be significantly less affected by a large increase in Ethereum transaction fees.

Moreover, we believe that there is high potential for securing any sort of information on the blockchain. The same procedure could be used to prove the authenticity, integrity and content of any document.

Acknowledgements

Special thanks to Manuel Gall, Fabian Lindner, Katrin Schuler, Antoine Verdon, Artan Veliju, Silvio Rainoldi, David Matter und Lukas Karth.

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Manuscript submitted: 10.03.2019
Manuscript accepted: 04.06.2019

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A trustless society?
A political look at the blockchain vision

Rainer Rehak

A lot of business and research effort currently deals with the so called decentralised ledger technology blockchain. Putting it to use carries the tempting promise to make the intermediaries of social interactions superfluous and furthermore keep secure track of all interactions. Currently intermediaries such as banks and notaries are necessary and must be trusted, which creates great dependencies, as the financial crisis of 2008 painfully demonstrated. Especially banks and notaries are said to become dispensable as a result of using the blockchain. But in real-world applications of the blockchain, the power of central actors does not dissolve, it only shifts to new, democratically illegitimate, uncontrolled or even uncontrollable power centers. As interesting as the blockchain technically is, it doesn't efficiently solve any real-world problem and is no substitute for traditional political processes or democratic regulation of power. Research efforts investigating the blockchain should be halted.

Numerous new blockchain research centers have recently been formed in universities all across Europe, the German federal government is working on a blockchain strategy and big blockchain conferences are being held worldwide. Having arrived at such level of attention, I want to take a closer look at the political implications of applying the blockchain technology to societally relevant services: Can this technology hold its general promises when practically applied or is it a hype actually being suitable for marginal use cases only? To guide this enquiry, I focus on understanding the political ramifications of a blockchain-based 'trustless' society in contrast to the current one.

Modern societies are based on trust: trust in other people, in certain procedures – such as democratic elections –, and in intermediary institutions such as banks. Without this generalized trust, complex societies based on the division of labour could not exist. Occasionally, however, this trust is fundamentally betrayed, and so it makes sense to look for new ways to minimize the need for trust in the societal coexistence. For that, I focus on the digital technology called blockchain, as applied in Bitcoin or Ethereum. The blockchain supposedly – if applied correctly – makes central intermediaries, so-called trusted third parties such as banks or notaries, superfluous. The blockchain should therefore solve the problem of creating a common consensus in a neutral technical-cryptographic way and no longer in an organisational way.

From a technical point of view, the blockchain is a mechanism for solving a problem which computer scientists call network consensus. The aim is to create and maintain a reliable common understanding concerning the current state of shared objects, even protected from manipulation. Classic examples of this problem are time synchronization, or the assignment of domain names to IP addresses. Every member of the network needs to have the same understanding – a common view – for the system to work. But the common logging of activities or monitoring value transactions are also instances of this problem. These do not only concern a current state, but also some kind of history containing past changes. So how can a network of distributed systems agree on what is currently "the case in the world"? The simplest solution to this problem is to have central authorities manage the task on behalf of the other systems involved and thus create coherence in a low-overhead and scalable manner. Ultimately however, in this setting, the power over all systems' common understanding is delegated to one or a few privileged central points which all parties must trust and which at best have no self-interest in manipulation. The blockchain attempts to prevent the concentration of power and vulnerability of those centralized approaches by technically forcing decentralisation, public reproducibility and immutability of data records. The blockchain therefore offers the functionality of a directory or ledger, but without (trusted) intermediaries, which is why the term "trustless" is often used.

How did this technology spread worldwide and can it keep the bold promises of its advocates in actual use cases? The blockchain-relevant topic of trust in intermediaries became crucial in 2008 due to the financial crisis and the resulting global recession. The key institutions – in this case, banks – had massively enriched themselves, manipulated relevant key figures, and thus produced a worldwide financial and trust fiasco, whose effects can still be seen globally today. However, banking regulations were neither significantly restricted, nor was a split-up of the big banks politically discussed. The banks were rescued with taxpayers' money and could essentially continue as before, while economies groaned worldwide and millions of people lost their savings, jobs, and homes. This (non-)reaction of state authorities to one of the most relevant events in recent economic history gave a huge boost to a subgroup within the critical tech community: the crypto-libertarians. They felt confirmed in their belief that any concentration of power does more harm than good – the only thing that counts is the free individual. From their perspective, one can and must use technical tools, in particular cryptographic ones, to defend against overbearing institutions. Even though this movement has existed for decades, its radical-individualist world-view began gaining traction outside its own ranks. In this situation, a person or group using the pseudonym Satoshi Nakamoto published a concept paper for an alternative global currency including its own means of payment – including usable software with the necessary cryptographic mechanisms. The crypto currency Bitcoin was born: a public distributed ledger without intermediaries securely documenting money transfers; in other words, a monetary system without banks.

Furthermore, this technology can not only be used for processing financial transactions, but also for recording any transaction of value or data and, due to the immutability of the transaction history, for reliably storing any information including executable programs. This abstraction and generalization of Bitcoin led to the blockchain technology, which can be utilised to process digital transactions, similar to a notary's office. In order to analyse the almost magical claim that a purely technically mediated and neutrally documented consensus can be achieved, I will briefly describe the mechanism of the blockchain. The blockchain consists of a chronologically ordered chain of data units, the so-called blocks, where each block contains a defined number of transactions and a cryptographically secure reference to the entire previous block. The whole blockchain thus contains the valid current state and the complete history of transactions in the network. A block cannot be changed afterwards, because otherwise the secure reference would be cut and following blocks would become invalid.

"The brilliance of the blockchain lies in the fact that all computers in the network concurrently try to form a new block using transactions not already stored in the blockchain. In effect, all computers independently try to solve a cryptographically complex task – a crypto puzzle." As soon as the first computer finds a solution it gets a (financial) reward. Immediately every other computer will stop working on the current block, and start creating the next block referencing the one just created by the winner – the chain just got extended. With Bitcoin, block creation happens approximately every ten minutes. The intention of the immense use of resources in the competition of parallel puzzle solving – the so-called mining – is that it is always another computer (equals: never the same) in the network creating a new block. So, if someone wanted to manipulate certain blocks to create an alternative history, that actor would have to be able to out-compute the rest of the network to stay ahead on every new block. This competitive model intends to prevent centralisation, hence allows for the system to work in a distributed manner. However, since the puzzle is a computationally intensive task, the probability of a solution increases with the computing power of the computer used.

Considering and contextualizing the technical properties, it is notable that a blockchain is technically decentralized, but – as commonly found in individualistic concepts – it assumes (actually requires) equally powerful actors. However, since generating a block in the Bitcoin network is financially rewarded, mining has been professionalised for several years now by merging computers and hardware specialisation. Commonly used laptops by private individuals now compete against storage building sized computing clusters equipped with highly customised graphics card chips – and practically always lose. This is because the computing power alone is decisive for winning the crypto puzzle and therefore successful block generation; it becomes obvious that the system has no internal mechanism to maintain its initial and intended decentralization. Depending on estimates, 50 to 60 percent of the so-called hash rate, i. e. the computing power of the entire Bitcoin network, is currently in the hands of the Chinese miner company Bitmain. This degree of centralization is comparable to or even greater than in the conventional banking system. In effect, in the largest active blockchain project decentralization is an illusion. Although the possibilities for manipulation are limited (for example, pending transactions can only be delayed or completely suppressed), the limitation explicitly does not originate from the system's (de)central character. It results from the publicly visible transaction records and the underlying asymmetric key cryptography for signing records. This kind of manipulation protection could also be easily achieved without using a blockchain. In addition, the blockchain understands decentralization only technically, not in terms of administrative power. So, if 90 percent of the individual computers in a network are under the control of a single person or organization, the network may still be distributed in a technical sense but concentrated from a power analysis perspective. This puts the expectations towards any blockchain-centric solution harshly into perspective.

The immutability analysis of the blockchain is also quite revealing from a political point of view. The concept of cryptographically secure logging is, in computer science terms, already ancient. It has been practically applied since at least the 1980s, for example in the form of *hash chains,* a way of storing data where every new record secures all previous ones. What is actually new with the blockchain is its distributed character, but this also has its own side effects. In 2016, for example, a programming error led to two parallel yet valid histories of the blockchain-based crypto currency Ethereum. To correct this fundamental defect, the two chains had to be laboriously reunited. Also, in 2016 a fully automated commercial organization called DAO (Decentralized Autonomous Organisation, a venture capital fund) was developed, but its code had bugs and was hacked. As a result, DAO was robbed of a third of its value in Etherium coins. The community could not agree on how to deal with this bug. Some wanted to fix the 'accident' and others wanted to stick to the immutability of history. Eventually the Ethereum blockchain was split up into one where the robbery had happened and one where it had not. Even Bitcoin itself had a blockchain split in 2017, as there was a dispute over technical parameters while extending the Bitcoin code basis. As a result, the parallel currency Bitcoin Cash was born.

In the light of those examples it turns out that the transaction log of a blockchain is technically unchangeable, but the usage contexts and social conditions of its real-world application have a great influence on the extent to which the technically implemented immutability is actually effective. Since the blockchain is software, changes of the kind previously described are caused by code changes. But not everyone can make changes to the code, so who decides in which direction the network is developed and how is it negotiated, if at all? If we state "code is law", then who is the "legislative"? Why are certain decisions implemented while others are not, and who does the proper implementing? Obviously, non-technical procedures – perhaps even quasi-democratic ones – for social negotiation, regulation, and conflict resolution play an essential role. But this was exactly what the blockchain originally wanted to make obsolete.

Another fundamental problem goes hand in hand with applying a blockchain to the physical world: Let us assume that a blockchain in fact ideally implemented the characteristics of immutability, publicity, distribution and thus, trustlessness: How could the correctness of the data stored in the blockchain be verified and ensured? Dealing with digital financial transactions is comparatively simple, since each person can only spend the money that is available in his/her own account. But as soon as it comes to claims about the physical world, such as whether cash or goods have been exchanged, or whether a piece property has been damaged, so that an insurance company would have to compensate, the blockchain only provides an immutable documentation of the allegations. The problem of correctness and reliability remains unsolved.

So far the eternal desire to solve social and societal problems through neutral technology remains unattainable, even with the blockchain. It does not make powerful intermediaries disappear, but only recreates them outside the scope of technology as can be observed with the advent of crypto currency exchanges centrally keeping many people's Bitcoins. Those new centres can be regulated and frequently betray their user, just like it was before. On the other hand, if the attempts to dissolve intermediaries were successful, they would plainly follow the neoliberal mantra of individualizing societal risks: Sole responsibility lies again on the shoulders of the individual person. Distressed are those who lose all their savings through a hack because their home computer and thus their Bitcoin wallet was not sufficiently secure. Distressed are those losing their retirement pay because the pension managing smart contract was poorly programmed. Maybe a small IT elite could profit from more freedom through blockchains, but the rest of society would most likely become more vulnerable; just like in medieval times of hiding one's money in bedsheets.

As a society, we have to make decisions: Is the illusion of getting along without trustworthy third parties really worth the massive resource expenditure of permanent parallel calculation? Certainly not. But can the foundation of society be reinforced by forging anti-institutionalism into technology? The answer to this question can be found in the Bitcoin blockchain: The absence of institutions counteracting power asymmetries ultimately leads to the anarcho-libertarian right of the (computationally) strongest. Those harsh results imply that public research on blockchain should be reduced to the few actual highly specialized technical use cases, while research funding for societal applications could and should be used much better elsewhere.

Ultimately, societal subsystems are always based on trust – the only relevant question is how trust can be negotiated and legitimized. Seen in this light, the Bitcoin project seems to be a well-hidden but very emphatic call for the overdue democratization of the banking system.

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The university as an open platform? A critique of agility

Elena Wilhelm

The agile organisation is a concept in a whole series of supposedly new organisational concepts of recent decades. The demand for agility in the organisational context is based on the assumption that the environment develops increasingly disruptively and that organisations must adapt agilely to these disruptive developments. However, the theory of disruptive development is fraught with problems, and, thus, the theoretical and empirical basis of justification for agile organisation is rather weak. The article discusses the dilemmas of agile universities in the form of nine theses. Agility does not solve the main problem of the lack of innovation. Agility, as defined by the majority, is a form of passivity towards the environment, yet it is not only about adaptation, but also about active transformation. We do not need more agility, but rather more innovation. The concluding remarks set out in four points what remains of agility for the university.[1]

1 Introduction

The *agile organisation* is an organisational concept in an entire series of new concepts of the last decade such as the "flexible" (Toffler, 1971), the "innovative" (Vrakking, 1990), the "learning" (Senge, 1990), the "intelligent" (Lambertz, 2018) and the "resilient" (Drath, 2018) organisation. I will clarify how the term has originated, what is meant by an agile organisation and what has previously been written about the agile university. Following this, I will draw a conclusion in the form of nine theses and explain how I perceive a promising development in universities against this backdrop. In my closing statement, I will present what, in my opinion, remains from the agility for a university.

Universities have long been accustomed to see themselves as institutions and not as organisations. Institutions are establishments that already fulfil their purpose with their establishment. Organisations, on the other hand, must explain themselves internally and externally and are in competition. Management is an organisation's answer to the challenge of having to substantiate decisions while weighing the alternatives (Baecker, 2017, pp. 19f.). To the extent to which universities are compelled to contemplate profiling, governance and financing, they must also inevitably be thought of under the

[1] The article is based on a presentation given by the author in Zurich in November 2018 at a conference on "Shaping the university with more agility".

perceptions of the organisation and, therefore, the management. This is arguably still more uncommon for universities than for universities of applied sciences, which have always viewed themselves as an organisation and have also not anchored any democratic structures expressed in the rather curious term of the *conducted university of applied sciences*.

2 The agile organisation

2.1 A concept from software development

The principle of agility originated among software developers. Initial attempts at agile software development were detected at the beginning of the 1990s. The principle gained prominence with the publication *"Extreme Programming"* (Beck & Andres, 2004). The term *agile* was chosen in 2001 at a meeting of software developers in Utah, a replacement for the heretofore common term "lightweight". The starting point was the criticism that the development of software is other than simply executable knowledge (Cockburn & Highsmith, 2001; Dingsøyr et al., 2012). Knowledge cannot be developed from the engineering perspective in the way a bridge or a high-rise building can be. Knowledge is found in a creative process. One reason for this is that in software development both the objectives and the environment (that is, the persons involved, the market demands, the technical environment and the interfaces) are flexible and change over the course of time. The Agile Manifesto was formulated at the meeting in Utah. The Manifesto reads: *"We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value: "Individuals and interactions over processes and tools; Working software over comprehensive documentation; Customer collaboration over contract negotiation; Responding to change over following a plan."* (Beck et al., 2001)

Agile processes and methods attempt to reduce the design phase to a minimum and to achieve executable software as early as possible in the development process which are then presented in regular, brief intervals – in so-called *sprints* – to the customer for collective coordination. This is a way to flexibly respond to customer requests at any time. Now there is a great number of agile processes and methods. Some of the most well-known are Adaptive Software Development (ASD), Crystal, Feature Driven Development (FDD), Extreme Programming (XP), Design Thinking, Kanban and Scrum.

2.2 Initial position: Theory of disruptive development

The principle of agility was transferred from software development to the design and management of organisations (Laloux, 2015; Robertson, 2016). In the management sector, the term stands for new project management methods but also for new management principles and for new organisational structures and cultures. The requirement of agility in the organisational context is based on the assumption that the environment continues to develop disruptively and organisations must agilely adapt themselves to these disruptive external developments. The founder of disruption theory is Clayton M. Christensen (Christensen, 1997; Christensen & Raynor, 2003). In his book, *"The Innovator's Dilemma"*, he demonstrates how businesses have slept through trends and thereby collapsed by using examples from the computer and steel industries. Disruptions will change entire business branches and products, and, according to Christensen, they force established businesses out of the market. Christensen has transferred the observation to the university and has written a voluminous book about the agile, or the innovative, university (Christensen & Eyring, 2011).

Christensen's theory of disruptive development is beset with several problems (King & Baatartogtokh, 2015; Lepore, 2014). It is historiography based on deeply-rooted anxiety towards financial collapse, an apocalyptic fear and, ultimately, insufficient empirical results (Lepore, 2014).

Methodically, Christensen's claims are not suitable for the assessment of successes and failures of businesses. His examples are, if anything, anecdotes. Selection criteria of the businesses and time periods studied are lacking. In many instances of his examples, long-operating businesses that capitalise on continuous development and stable structures have actually maintained their market share and even expanded when observed over a longer period of time, while disruptive, newly established businesses were able to attain success in their initial periods but were bought up or became insolvent over the mid- and long-term. The advantage of start-ups is not necessarily their agility but rather the fact that they do not have any previous activities to protect. They are not encumbered in their new activity by their previous financial, intellectual and emotional investments in their new activity.

2.3 Agility as a management concept

Despite this rather problematic and empirically insufficiently justified starting point for the agile organisation, we shall look at what exactly is meant with agility in an organisational context.

Until now, there has not been a consistent and concise definition of agility, and a number of similar terms have been used to describe agility. For an overview of various definitions, see Jafarnejad & Shahaie, 2008. The discussion of the concept of flexibility, formerly termed elasticity, has already been going on for 90 years (Termer 2016, p. 16). Frank Termer makes a comparison of the definitions of agility and flexibility and explains that a distinct conceptual separation has not as yet been accomplished. There are great overlaps and both concepts are, in part, identical content-wise. Nevertheless, I will henceforth attempt to outline which general derivations from the agile software development can be undertaken with respect to the organisational action under the concept of the agile organisation.

The *agilists* are eligible to fundamentally change the manner in which organisations function. Agility is the capability of a business to continuously adapt itself to its complex, turbulent and unstable environment (Goldman et al., 1996). In order to do so, it must develop the ability to anticipate these changes, to be ready to adapt, to constantly learn as an organisation and to make this knowledge available to all relevant persons (Dove, 2001). To achieve this, the organisation of the future is an extensive non-hierarchical, democratic organisation in which the well-being of the customers and the employees is priority (Kühl, 2015a, p. 17). A basic manual for this is the book "Reinventing Organizations" by Frederic Laloux (2015). Conventional organisational structures are process- or project-oriented or a combination of the two. The agility concept implies that organisations in the context of an inconstant and unstable environment with these structures cannot keep up with the transformation. The internal organisation of agile businesses orients itself on the maxim of absolute adaptability. Structures are, therefore, only loosely connected. It is consequently dehierarchised and decentralised (Kühl, 2015a, p. 23). The differentiation in divisions is increasingly dissipating. The new organisational structures require an intensive, informal, non-formalised communication. Temporary project groups secure the innovation process.

Jack Welch, former CEO of General Electric, already wonderfully expressed the agile principle in 1989, although not under the concept of agility:

> *"Our dream for the 1990s is a boundary-less Company, a Company where we knock down the walls that separate us from each other on the inside and from our key constituencies on the outside. The boundary-less Company we envision will remove the barriers among engineering, manufacturing, marketing, sales and customer service; it will recognize no distinctions between ‹domestic› and ‹foreign› operations. We'll be as comfortable doing business in Budapest and Seoul as we are in Louisville and Schenectady. A boundary-less organization will ignore or erase group labels such as ‹management›, ‹salaried› or ‹hourly›, which get in the way of people working together. A boundary-less Company will level its external walls as well, reaching out to key suppliers to make them part of a single process in which they and we join hands and intellects in a common purpose – satisfying customers. This is an admittedly grand vision, requiring an unprecedented cultural change, and we are nowhere near achieving it. But we have an idea of how to get there – an idea that is rapidly becoming reality across the Company. It's called Work-Out. Work-Out is a fluid and adaptable concept, not a program."* (Welch, 1990)

Jack Welch's speech illustrates the direction of impact of agile businesses: In agile organisations, rigid structures are replaced with loosely coupled structures. This occurs with the termination of boundaries, internally and externally, the dissolution of functional differentiations, a dehierarchisation and decentralisation (Kühl, 2015a, pp. 52ff.).

Positively formulated, it is a merger, both internal and external, the integration of various areas of responsibility, the democratisation and sociocratisation and a grassroots ensconced responsibility.

According to the agile approach, division of labour and specialisation lead to inflexibility and a lack of professional and personal flexibility. In agile organisations, diverse functions are merged. Employees are brought together around tasks. Job profiles are obsolete. Hierarchy is almost a curse word in agile organisations. The vertical differentiation is widely disassembled, and the permeability between the remaining levels is consequently strengthened. The dissolution of vertical and horizontal differentiation leads to a consequent decentralisation.

A common metaphor for agile organisations is the jazz band which is about the integration of creative transpositions. The harmony of the organisation is based on the ability of the employees to apply their competencies in the right moment and pass the topic along to the colleagues: Individuality and integration capacity are equally sought (Kühl, 2015a, p. 58). Jazz bands are examples for agile co-operations. According to Leue (as cited in Früh, 2015a):

> *"There is no doubt about what music is played. Also, if only a few details are stipulated in written form – in the selection of the individuals, in the selected individual, in the pieces and in the collective style – it clearly indicates towards which guidelines the members of the band orient themselves. The prescribed arrangement allows for freedom for the individual. He creates his freedom, relying on familiar components, arranges them anew while inventing some in the process"* (Früh, 2015a, p. 59) (translation by the author)

Dissolution of boundaries from within and without, resolution of functional differentiation, decentralisation, dehierarchisation, deformalisation of communication: This is the objective of agile organisations. Unstable structures, loose couplings and composite systems of independent intensive training centres, temporary project groups and semi-autonomous work groups form its core (Kühl, 2015a, p. 67).

In the appendix of his book, Frederic Laloux explains (Laloux, 2015, pp. 318–322) how the structures, practices and processes of agile organisations (he calls them evolutionary organisations) look. It is a wonderful social and human prose: self-organised, spontaneous, radically simple, voluntary, reasonable, free, culture forming, flexible, honest, fair, just, attentive, independent, completely decentralised, holacratic, vibrant, completely transparent, upright, beautiful, exempt of target and budget and so on and so on. It is not coincidental that the afterword is by Ken Wilber, the American consciousness researcher. It almost gives the book a biblical character.

3 The agile university

What exactly does all of this mean for a university? Until now, relatively little has been written about the agile university (Baecker, 2017; Masson, 2012; Twidale & Nichols, 2013).

The sociologist Dirk Baecker assumes in his article "Agility at the University" that universities have, in a sense, always been agile but that they must, nevertheless, continuously and increasingly orient themselves towards agility (Baecker, 2017). Under an agile university, Baecker understands a specific management concept, particularly, in which vertical structures are converted to horizontal structures. Admittedly, universities had always more or less practised this form of management as well because universities are oriented in their practice and in their knowledge towards the difference between internal and external and not towards the difference between top and bottom (Baecker, 2017, p. 22). The research practice of the professorships and the knowledge taught by the faculties are organised in a manner that defies every hierarchical ranking.

The still existing hierarchy must be replaced, states Baecker, by means of an agile discussion, with complexity in the form of projects. In the end, the university is both platform and technical infrastructure. An empty diagram, stage, interface, as Baecker writes, while at the same time: program, protocol and register. At this platform university *"projects that deserve the name agility prove, measure and apply how digital devices still allow us freedom for human initiatives"*. (Baecker, 2017, p. 26) In the end, Dirk Baecker even becomes dystopian. This time his contribution is rather impenetrable. Baecker offers us a few compatible fragments.

Patrick Masson, Director of the Open Education Consortium and Special Advisor at the University of Massachusetts, tells us that it is not a dystopia but rather a utopia (Masson, 2012). For him, the agile university is also, ultimately, only a platform which makes it easy for groups to gather. Patrick Masson views the platform "Wikipedia" as a possible ideal. The university becomes the "Agora" or a "hothouse" as defined by Barton Kunstler (2005): It offers an environment in which creative and innovative activities flourish. Its boundaries are permeable. The entry and exit of the participants are simple. The agile university as a platform is not familiar with any formal approval processes. The activities that take place within the platform are unplanned and are defined by the interactions between the "inhabitants" of the platform. The platform is unstable ("protean") and changeable. Activity clusters are born, thrive and die if necessary. Participation follows the power law: A few very active participants are followed by a large crowd of occasional participants.

The agile university consists of voluntary and self-organised associations of lecturers and students. The curricula are self-organised and fluid, based on the interests of the faculties and the needs of the students. The university no longer offers employment. Stability is determined by the entire community, which moves fluidly back and forth between the economy, society and university. There are no administrative rules, but rather protocols on which the values of the community are based. The agile university also does not award diplomas. However, the faculties award individual certificates. The agile university encourages play, failure and experiment and makes all knowledge created at the university available to all for free. It has a fluid temporal structure: There are no semesters, and the teaching and learning is a continuous activity. The agile university is not entirely free of management. It is not managed exclusively by planning but rather by coordination. The president is host and "Choice Architect" (Thaler et al., 2010). He or she is "Chief Organizer" or "Scrum Master", eases communication, offers to coach and removes obstacles. The president leads with "cultivation and care" and not with "management and control". And he or she loves surprises.

Furthermore, even this university utopia is not new in many aspects. For example, Clark Kerr, former president of the University of California (as cited in von Wissel, 2007, p. 277), had already drawn up the "multiversity" in the 1960s: a multiple, open, flexible, permanently international, entrepreneurial university.

While these texts have motivating potential about the agile university, the texts on agile teaching and learning at universities leave one rather irritatingly behind. The "Agile Teaching and Learning Methodology" (ATML) (Chun 2004) and "Just-in-Time-Teaching" (JiTT) (Novak 1999, 2011) assume that teaching and learning processes run just like software development processes (Chun, 2004, p. 2; Meissner & Stenger, 2014, p. 127). In agile teaching and learning, the students assume the role of the customer. The agile software development process in which the customers are involved is replaced by the learning/teaching process in which, one reads and is astonished, – the students are involved. The continuous growth in the students' competences in the agile teaching and learning process conforms to the increments in which the sprints realise new functionality (Meissner & Stenger, 2014, p. 127). We have an odd backflow here: The agile software developers orient themselves towards the way in which knowledge originates, in other words, towards a process of knowledge creation. They in turn apply this same orientation towards agile teaching and learning. It is now called "Just-In-Time-Teaching" and "agile teaching and learning", which, simply put, means that one guides the students in their education process and, hopefully, gives them proper feedback.

There are other similarly absurd backflows of software development applied to teaching and learning, for example from Jörn Fahsel or Michael Twidale and David Nichols. For Fahsel, the agile theory must fulfil the following conditions: There must be a person who can provide and convey knowledge and experience; this person must be accessible as a contact person during the learning process and make relevant knowledge available. Once the students have dealt with the knowledge, they should purposefully ask the lecturer to clarify ambiguities and obtain new input (Fahsel et al., 2016). In their article "Agile Methods for Agile Universities", Michael Twidale and David Nichols formulate an agile manifesto for the lectureship of a university or, as they call it, for a "Developing of Students". By analogy to the Agile Manifesto for the software developers, they claim the following for universities: individuals and interactions prevail over processes and tools; demonstrable student achievements prevail over comprehensive documentation of these accomplishments, that dynamic learning discussions with students prevail over documents, metrics and policies, and that the reaction to changes is more important than following a plan (Twidale & Nichols, 2012, p. 10).

Convincing concepts for an agile university do not exist. The utopia of the "university as an open platform" (Masson, 2012) offers motivating ideas to be pursued further. However, the sifted articles on agile teaching and learning do not open new perspectives.

I will draw a personal conclusion in the form of nine theses and in a concluding final statement from my, at times, onerous analysis of agility, agile organisations, and agile universities. In doing so, I will take the liberty to go beyond agility and explain how, in my opinion, a university should position and transform itself in the future:

4 The dilemmas of agile organisations: Conclusion in nine theses and closing statement

(1) *Both the feeling that the requirements are becoming more complex and the principles of agility are not new.* The dynamic of changes we observe here was also recognised by managers in the high phase of industrialisation at the end of the nineteenth century, in the 1920s and in the 1970s. The introduction of the railway and the telephone massively altered the perception of speed and complexity as well. The demand for agility is also based on a dramatisation of the dynamic of development. The regard for historical developments sets the current changes into perspective.

(2) *The current management literature does not have convincing and consistent concepts for a new, agile organisational form.* In the case of the agility concept, it is a new packaging of post-bureaucratic organisational principles that have been known for a long, long time. Decades ago, semi-autonomous work and production groups that are continuously propagated as a new concept under new names in regular intervals were already being discussed (Fotilas, 1980; Antoni, 1996). The demand for the dehierarchisation of organisations is already found in the "Management Pioneer" Mary Parker Follett who, as cited in Kühl (2015a), in the 1940s, demanded that the vertical authority in organisations be replaced by a horizontal authority. Even the project-based work at universities in functionally mixed teams with iterative project methodology and spontaneous orientations in terms of "Scrum" is not at all new. I have been working almost exclusively in this manner parallel to the line management for two decades.

(3) *There is no large organisation and no university that manages without a hierarchy.* Organisations and universities are still based, to a considerable extent, on the hierarchy principle and will do so in the future as well. Nevertheless, this is no defence of still existing, too steep hierarchical gradients at universities and the academic precarity but rather much more a plea for strong university management equipped with relevant competence that advocates and can advocate for the entire university campus.

(4) *Organisations that decentralise decision-making abilities see themselves confronted with fundamental coordination problems* (Kühl, 2015b, p. 10). The more independent the entities of an organisation become the more urgent and, at the same time, the more complicated the integration of these entities into the whole organisation becomes. Integration becomes increasingly more difficult but, at the same time, increasingly more necessary with the growing differentiation in self-organised, semi-autonomous entities (Kühl, 2015b, p. 10). Employees lose a clear image of their organisation, which can result in an identity dilemma. Distribution in autonomous, small entities tends to lead to innovation policy being taken in small steps and includes the risk that the same competencies are being built at different points in an organization (Kühl, 2015a, p. 91). In my opinion, it would be wrong to decentralise universities more than this. In order to remain viable, decision-making abilities at universities must rather be centralised today. This is possible without undermining the specific cultures and goals of the different faculties or departments or the academic freedom of teaching and research.

(5) *Agile Organisations will fail due to an excess of internal instability.* They are facing the dilemma of needing to stabilise themselves although flexibility is vital for them. The obligation to agility creates instability and new fields of power. Hierarchy and distinct distribution of competencies are no longer available as regulatory mechanisms in power struggles. Permanent negotiation processes which lead to a

constant politicisation of internal decisions are required (Kühl, 2015a, p. 23). Presumed simplification strategies lead to a growing complexity, which should not be perceived as such (dilemma of complexity) (Kühl, 2015a, p. 9).

(6) *Agility does not solve the main problem of lack of innovation.* Agility, as it is predominantly defined, is essentially a form of passivity towards the environment. It is not only about adaptation but also about active transformation (Silberzahn, 2017). For example, the world to which Swatch should have adapted itself was a world in which 90 per cent of the world clocks were manufactured by low-cost manufacturers. The world to which ZARA had to adapt itself was a world in which it seemed apparent that no European low-cost textile manufacturer would survive. Rather than adapt to this world by being "agile", these companies questioned this assumption. They did not adapt to the surroundings but changed them. They were not agile but transformative (Silberzahn, 2017).

(7) *Thus, we do not need more agility but, first and foremost, more innovation.* We must determine the fields of the university that promote innovation and transformation. In my opinion, these are, above all, the fields of education and infrastructures. We must individualise and make the contents and formats of our educational opportunities flexible. Perhaps in the future, there will no longer be any degree programmes as in the contemporary understanding. In the field of infrastructures, alliances between various universities and industry will increase in significance. The universities must decide in which areas they will offer infrastructure and in which areas they will receive infrastructure.

(8) *Development and maintenance of inter-organisational relations will become one of the most important tasks of university management.* Currently, competing means cleverly positioning one's own university in a network. A functional division of labour among the universities and the prioritisation of universities become more relevant. Specific complimentary cooperation between the types of universities serves to raise their profile in the competitive international environment and to establish dual institutes that offer broad and in-depth educational and learning methods, a stronger integrated curriculum and collective research platforms. Universities will form more niche partnerships that are based on either collective visions or on complimentary capacities.

(9) *The regional connection of a university is critical for the versatility and flexibility of the university profile.* The profile of a university or a university network thrives on symbiosis with the regional, social and economic realities. Regional innovation systems increase in significance such as, for example, the research association "Cyber Valley" that was recently founded in the region of Stuttgart-Tübingen. Intermediary knowledge-sharing institutions will gain in relevance. Application-oriented research will increasingly be for industry-driven application development

(via the product design for the development of a supply chain); the university will become a production site. Nevertheless, we must take care that, as a university, we do not lose the internal cohesion for all openings. A limitless transgression is not desirable. The basic research and the ivory tower as a metaphor for a safe haven of knowledge must be strongly defended.

5 Closing Statement: What remains from agility for the university

There are four aspects in my opinion:

First, the necessity of the delegation of selected decision-making functions downwards and, with it, the simplification and acceleration of specific processes. We can, in fact, learn this from the agilists. For example, it cannot be the case that new courses of study have to be examined and approved several times by university councils. The development of educational opportunities must be swifter and more spontaneous in the future.

Second, an understanding of strategy as a movement and not as a programme. A university strategy can no longer codify any programme today but rather must have the strength to initiate a movement. It must support and facilitate an explorative and experimental approach as long as it is long-term and evolutionary invested.

Third, the punctual experimenting with Masson's utopia. Patrick Masson's "University as an Open Platform" is, however, not a substitute but rather meant to be integrative. We must create more self-governing, explorative, and open sites and spaces. There are models for this in, for example, "Code University" in Berlin, "École 42" in Paris or the Media Lab of Massachusetts Institute of Technology in Boston.

Fourth and, in conclusion, all this requires a strongly developed, anticipative ability. A strategic observatory is indispensable for every university or every higher education area. It promotes the ability to expand and utilise the existing system capacity. Agility, understood in these terms, is a mode to create the environment rather than to adapt to it.

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Hochschulforschung und Hochschulplanung

In this issue

ISSN (Print) 0171-645X
ISSN (Online) 2567-8841