Blockchain Technologies in the Educational Sector. Results of the Initial Data Collection.

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Abstract: The education system is subject to an ongoing digital transformation. The administrative departments should be able to handle grading, admissions, enrolments and recognition of certificates securely and quickly. Course managers should not only have faith in e-learning but also in e-assessment. And finally, learners should be able to access course material from anywhere and take exams outside the institutes where they are enrolled. Immutability to changes made retroactively seem to make Blockchain systems the perfect technology to secure data and in combination with digital signatures for identity verification, Blockchain could become the key to digital transformation in education. The paper 'Blockchain technologies in the educational sector Results of the initial data collection' gives a first insight into the level of knowledge of people involved and shows which possibilities Blockchain Technologies could bring to the education sector. Or, more precisely, it shows in which existing applications within the educational system Blockchain Technology should be integrated.

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Introduction

The education system is subject to an ongoing digital transformation. The administrative departments should be able to handle grading, admissions, enrolments and recognition of certificates securely and quickly. Course managers should not only have faith in e-learning but also in e-assessment. And finally, learners should be able to access course material from anywhere and take exams outside the institutes where they are enrolled. Immutability to changes made retroactively (generally speaking and ignoring software bugs or hacks that have already affected some systems (1),(2),(3) make Blockchain systems the perfect technology to secure data. (Atzei et. al, 2017; Schmidt, 2019). Before we look specifically into Blockchain in education and especially at the findings of the survey, and the focus group discussion in particular, a brief introduction to Blockchain technologies is necessary:

Grech and Camilleri (2017) describe in their report 'Blockchain in Education, Publications Office of the European Union' the (positive) effects of Blockchain Technologies as follows:

> *From a social perspective, Blockchain technology offers significant possibilities beyond those currently available. In particular, moving records to the Blockchain can allow for:*
> *1) Self-sovereignty, i.e. for users to identify themselves while at the same time maintaining control over the storage and management of their personal data;*
> *2) Trust, i.e. for a technical infrastructure that gives people enough confidence in its operations to carry through with transactions such as payments or the issue of certificates;*
> *3) Transparency & provenance, i.e. for users to conduct transactions in knowledge that each party has the capacity to enter into that transaction;*
> *4) Immutability, i.e. for records to be written and stored permanently, without the possibility of modification;*
> *5) Disintermediation, i.e. the removal of the need for a central controlling authority to manage transactions or keep records;*
> *6) Collaboration, i.e. the ability of parties to transact directly with each other without the need for mediating third parties. (Grech and Camilleri, 2017 p 8)*

The concept of Blockchain, as we know it today, derives from Satashi Nakomoto's Whitepaper 'Bitcoin: A Peer-to-Peer Electronic Cash System', published in late 2008. (Satashi Nokamoto is a pseudonym, it is not known to the general public who is behind this name.) Originally intended to create a non-manipulable account book to represent the possession of digital tokens, which in turn are traded for money on exchanges or over-the-counter (peer2peer), it is now about the technology behind it and what applications can possibly be developed using Blockchain technology to secure transactions. The idea of using the Bitcoin Blockchain for more than 'proof of payment transactions' arose from the fact that you can attach text messages to a transaction. To create an account book of any imaginable transaction, a fraction of Bitcoin (so-called Satoshis) is being send to an address and the text to be recorded was attached to it as a text message and thus stored forever on Blockchain. Blockcerts, a solution invented at MIT to store/verify learning credentials (4), uses this principle to store the data on the Bitcoin Blockchain (it verifies an original document using a 1-way hash).

However, if information of all applications is stored only as a text message attached to the same kind of token, strongly limits in the range of possible applications. And since Bitcoin was not originally intended for other applications apartment from payment, the idea came up in early 2010 to develop a network in which sub-tokens (metatokens) can be generated for a specific application. The Blockchain systems NXT and Ethereum are particularly noteworthy in this context from a historical as well as actual perspective. NXT [5] because it was the first Proof of Stake (PoS) system, a different approach regarding consensus finding to Proof of Work (PoW), which is btw. considered environmentally friendly. Ethereum [6] because it is the second most important Blockchain system after Bitcoin, especially if you look by market capitalization. Both Blockchain-systems mentioned also have another special feature. The possibility to develop smart

contracts. While Ethereum makes this possible with Solidity, a specially created programming language, NXT uses so-called lightweight smart contracts in Java. This offers less design freedom, but potentially a higher level of security. In principle, smart contracts are nothing else than the digital, (partially) automated and secure processing of contract scenarios. At this point is also very important to mention that generally Blockchains can be classified into three major categories. (see e.g. Wan et. al, 2019):

1) Private Blockchain: is basically a closed system and exclusively operated within organizations, businesses, or government structures. No information is disclosed to the outside world, except, where appropriate, evidence of a transaction that has taken place.
2) Consortium Blockchain: serves related parties that have a common goal, and organizations can join the consortium Blockchain on common agreements. Again, no information is disclosed to the outside world, except, where appropriate, evidence of a transaction that has taken place.
3) Public Blockchain: has no restrictions regarding joining/or leaving Blockchain. All information is public, although it is possible to store some information in encrypted form.

Pfeiffer (2019) created a comparison table to compare Blockchain systems on which sub-tokens/metatokens or also often referred as utility tokens (all meaning tokens with a specific purpose, possibly other than use as means of payment) can be generated. Besides the already mentioned system NXT and Ethereum there are (among others) Ardor, Cardano, Ethereum Classic, NEM, NEO, Tron or Waves worth mentioning. Nevertheless, due to the decentralized development, the still short time (10 years) of the Blockchain idea itself and the interest of industry and society even more recently, there is still no satisfactory standardized "wording" or "definition" of the different types of tokens (7), (8), (9), (10), (11), (12) especially an urgently needed differentiation of various different utility tokens according to their use cases. This classification could ensure that a different legal perspective applies to different cases. Therefore Pfeiffer (2020) proposed a segmentation regarding Blockchain-based assets The following asset class, which (for the respective purpose) represents a sub- or metatoken on one of the above-mentioned networks, could turn out to be particularly important for the use of Blockchain in the educational sector

> *Non-freely tradeable utility tokens: These tokens store data, such as certificates, grades or a last will; they can be a unique (singleton) token per record or a message attached to a specific token when sending. […] This data is usually linked to a person or a property and is not (or only under specific circumstances) tradable.*

How should Blockchain technology be applied in education? And what is the state of knowledge on this topic from the involved professional fields? The following results are intended to show the status quo.

Methodology

A hybrid approach consisting of a qualitative and a quantitative method has been used.

In moderated focus group discussion was chosen as the qualitative method. This was evaluated on the basis of Mayring's model of qualitative content analysis (2008,2010). The group consisted of 10 people (five teachers, three of them also with administrative roles within their institution (High-School, College, University), three researchers (in the fields of Blockchain, Education, Sociology) and two full-stack developers. The participants have been from different European countries (Luxembourg, Austria, Italy and the USA) The focus group discussion took place at [university not shown, due to peer-review] in July 2019. Descriptive statistics were conducted as a quantitative method. The data material was taken from an online survey (n=150) conducted between August and October 2019. As an initial question the participants could choose from which perspective the questions were answered. The choices were as follows: Teacher, IT professional, researcher in a related field or someone who feels being part of the Blockchain community. There was no reward for filling out the questionnaire in order to reduce incorrectly filled out questionnaires as best as possible. It was possible to skip any question.

Table 1. From which perspective did the interviewees of the online survey answer.

A Person…	Number of participants in the online survey
working as an educator	45

working as an IT-professional	30
working as a researcher in a related field	19
Blockchain Community	48
n=146 / skipped 4	

Research Question

1) At what point in time and why did the interviewees learn about Blockchain as technology?
2) How do the interviewees assess their knowledge of the Blockchain? And have they already made a transaction on Blockchain basis or at least observed it?
3) From which sources do the interviewees obtain information about Blockchain?
4) Which Blockchain systems are known to the interviewees?
5) Which steps are necessary before considering using Blockchain in education?
6) Where, in the education system, is Blockchain to be used? Or where is this particularly useful?

As a final question, the participants of the online questionnaire as well as the focus group were able to bring further points into the discussion that had not yet been mentioned.

Limitations

Due to the personal selection of the focus group participants by the author of the study, there is a certain limitation, which might have been less if the persons had been selected by an agency. On the other hand, the personal selection by the author of the study means that the interviewees are of high calibre. The limitation of the quantitative study is, on the one hand, that the assignment of professions was only made on the basis of self-selection. Furthermore, no personal data (age, gender, origin) were collected. From the point of view of the author of the study, however, this is not necessary for an initial survey and it does not lead to any data protection concerns. Possibly this might even lead to more honest answers.

Findings

The above questions are now answered from the point of view of all professional groups involved, although with a special perspective from the perspective of educators. Additionally, the analysis of each question is completed with the results of the content analysis of the focus group.

At what point in time and why did the interviewees learn about Blockchain as technology?

Table 2. Top five years in which the interviewees learned about Blockchain (and comparison to 2019)

IT Professionals / Researchers / BC Community		Educators	
Year	Percentage	Year	Percentage
2017	27,00%	2018	22,22 %
2013	16,00%	2017	15,56 %
2016	13,00%	2013	11,11 %
2011	9,00%	2016	11,11 %
2014	8,00%	2015	8,89 %
2019	0 %	2019	4,44 %
IT Professionals / Researchers / BC Community n=101 / skipped 1 | teachers: n=45 / skipped 0			

In late December 2017, Bitcoin reached its previous record high of just over US$ 20,000[1], the total market capitalization of traded Blockchain based tokens was several hundred trillion. As a result, the broad media landscape has reported extensively on the topic of Blockchain and especially bitcoin and the speculative

[1] Update: At the time this paper passed the review and is in print the all time high was 40,000 US$ in April 2021.

hype, and many people have heard about it for the first time. This continued into the beginning of 2018, until the bear market started in February 2018, which has not yet completely ended (13). In october 2013 the money laundering scandal surrounding Silk-Road, a trading exchange in the dark web (14), became known. This led to the first major coverage of Bitcoin and Although it was not a positive matter it fueled the first major wave of speculation. At the end of 2013 Bitcoin was traded for the first time around US$ 1.000, and similar to 2018, a long bear marked started in the first quarter of 2014.

In 2019, 0 % of the group of responders including IT Professionals / Researchers / Blockchain Community heard about Bitcoin and Blockchain for the first time, on the other hand still 4,44 % of the teachers learned about Blockchain the first time in 2019. However, this shows that the term per se (without judging whether one can explain exactly what it is) has thus become a term that is already widely known.

How do the interviewees assess their knowledge of the Blockchain? And have they already made a transaction on Blockchain basis or at least observed it?

Table 3. Knowledge about Blockchain, self-estimation.

IT Professionals / Researchers / BC Community		Educators	
Number of interviewees	Weighted Average	Number of interviewees	Weighted Average
100	4,19	43	2,67
Scale: 1: no knowledge to 7: very high knowledge			
IT Professionals / Researchers / BC Community n=101 / skipped 1| teachers: n=43 / skipped 2			

The group of 'IT Professionals / Researchers / BC Community' estimates their knowledge of Blockchain technologies to be slightly above average with a mean value of 4.19, the 'Educators' consider their level of knowledge to be below average with a mean value of 2.69. The results can be interpreted with the answers from the open answer field to this question and the summary of the focus group as follows: For the group of 'IT Professionals / Researchers / BC Community' it is difficult to keep up with the rapid technical development, especially in the last three years. In particular, it is difficult to distinguish marketing talk from actual innovations. And innovations have to undergo a stress test or code review. There are also still few offers in the university sector, especially interdepartmental activities are still not promoted enough and there are hardly any interactions with corresponding labs at the universities. In the area of teacher training, there are still hardly any offers, or, if they exist, they are still being actively used by too few people, since there is currently no basic understanding of Blockchain in the education system.

75 % from the ‘IT Professionals / Researchers / BC Community‘ group of people have already carried out a transaction on a Blockchain basis, 9 % have observed with someone else. Among the target group ‘Educators‘ this is much lower. 31.11 % have already interacted with Blockchain technologies themselves and 6.67 % have witnessed how a transaction works. This shows that conducting Blockchain transactions is not yet ‘mainstream‘ and underlines the thesis from above that there are still too few continuing education offerings for educators.

From which sources do the interviewees obtain information about Blockchain?

Table 4. Source of information

All Interviewees together (multiple responses possible)					
#	Source	Percentage	#	Source	Percentage
1	Reddit	48,61%	9	Participating at Lectures	27,08%
2	YouTube (Online Video)	47,92%	10	Friends & family	27,08%
3	Blogs	43,75%	11	Git-Hub and/or similar ressources	25,00%
4	Colleagues / at work	41,67%	12	Academic Journals	22,22%
5	Twitter	38,89%	13	Magazines	20,14%
6	Medium.com	36,81%	14	Books	18,75%
7	Reading Whitepapers	36,11%	15	Other Sources	13,89%
8	Newspapers	30,56%	16	TV & Radio	11,81%
All interviewees n=144 / skipped 6					

When asked where the information about Blockchain is obtained, sources available on the Internet are at the forefront. Redit, online video portals such as YouTube, blogs (especially Medium.com) and Twitter are the main sources, with responses ranging from 38% to just under 50%. Colleagues at work also play a major role with 41.67 %, while family and friends account for 27.08 %. Classical TV or radio, as well as books are under 20 %. Daily newspapers also do not play a very big role with 30 %. The interpretation of the results by the focus group shows that the Blockchain community usually has a high affinity for IT and also contributes a lot to the discussion in the form of contributions on Redit. In addition, there are people from the financial sector who use YouTube in particular for their analyses. Both groups like to blog, in their own blogs, on Wordpress or Medium.com. In the classic media sector there is a lack of well-trained journalists and the articles are often only superficial. According to the IT experts and scientists from the focus group, these articles often contain false information.

Which Blockchain systems are known to the interviewees?

Table 5. Which Blockchain networks are known to the interviewees?

All Interviewees together (multiple responses possible)					
#	Name of the Network	Percentage	#	Name of the Network	Percentage
1	Bitcoin	93,10%	12	Binance Coin	51,03%
2	Ethereum	80,69%	13	Stellar	51,03%
3	Bitcoin Cash	69,66%	14	EOS	50,34%
4	Litecoin	68,97%	15	Bitcoin SV	49,66%
5	Ethereum Classic	59,31%	16	Tron	47,59%
6	Ripple	58,62%	17	Cardano	44,83%
7	Monero	54,48%	18	Neo	44,14%
8	IOTA	53,79%	19	NXT	40,00%
9	Dogecoin	53,79%	20	NEM	36,55%
10	Tether	53,10%	21	Ardor	35,86%
11	Dash	53,10%	22	Others	26,21%
All interviewees n=145 / skipped 5					

Bitcoin with 93.10 % is clearly the best known Blockchain network and a synonym for Blockchain technology itself. 80.69 % know Ethereum, a network which allows smart-contracts and the creation of sub-/metatokens. The original Ethereum network is still known by just under 60%. With just under 70% still very well known is Bitcoin Cash (the first big fork (15) of the Bitcoin network) and Litecoin, the first network which builds on the Bitcoin source code to create a new network with some changes (total number of coins, speed of block generation). Networks like NXT, Ardor or NEM, although quite popular with the developer community and technically mature, can be found at the lower end of the scale in the survey. According to the focus group, this is often due to the fact that there is little or no advertising budget available to promote the system tokens, or that this is deliberately not wanted in order to avoid being placed in the speculation corner.

Which steps are necessary before considering using Blockchain in education?

Table 6. Necessary steps, before considering using Blockchain in education

All Interviewees together (multiple responses possible)	Weighted Average
Basic information/education about Blockchain-technologies for all people involved in the educational sector	4,17
Sophisticated privacy-settings	4,17
Clear and transparent rules about who is responsible for payment of fees	4,17
In-depth education about Blockchain-technologies for IT-professionals and administrative-officers in the educational-sector	4,15
The ability to get a copy of my own data that can be stored on my own node, regardless of which Blockchain system was originally used.	3,82

The possibility to process information from various Blockchain-systems	3,78
Everything has to be set up with open-source technologies	3,74
The ability to operate a full node and store an encrypted copy of the Blockchain used to store credentials	3,48
Having a close look if and which patents are involved within the used technology	3,39
Involvement of Government, strict worldwide regulation	3,01
Involvement of Government, strict local regulation	2,86
Involving corporations in the process of setting up Blockchain-technologies in the educational sector	2,86
All interviewees n=144 / skipped 6	

When asked which steps are necessary, it was possible to choose from various given answers, which were mentioned within the focus group. The scale was divided from 7=very important to 1=not important. With 4.17 clearly above the average, a basic training for all persons from the education sector, a clear solution as to how and who pays the transaction fees (should a public Blockchain be used) and a modern solution in the area of privacy settings were ranked. Further relevant points are an in-depth training for the IT staff in the education sector, a solution that includes different Blockchain systems, the open-source idea and the possibility to have your own data, or even to operate your own node. The interviewees are undecided in the area of regulation and whether large companies should push the developments. Here the score is even below average (2.86).

Where, in the education system, is Blockchain to be used? Or where is this particularly useful?

Table 7. Usecases for Blockchain in the educational sector

All Interviewees together (multiple responses possible)	Weighted Average
Handle payment transactions, for example for course fees	4,25
Taking exams "off-school/university/education center", assuming a suitable ID-checking solution is in place	4,11
Storing the successful completion of a course or class, without any specific grades	4,09
Storing grades at the end of the term	4,03
Handling of votings (e.g. vote for school representatives)	4,01
Scholarship processing and funding management	3,79
Storing competence profiles at the end of the term	3,73
Storing each test completed that has been completed during a term	3,62
Adapting digital serious games for use as assessment tools	3,61
Storing each step/chapter of an exam through e-learning tools while being examined	3,44
Class book and validated communication with parents/relatives	3,27
Storing a behavioural grade at the end of the term	3,2
All interviewees n=144 / skipped 6	

In which areas should Blockchain technologies now be used in education. For this final question, a rating between 1 (not suitable) and 7 (very suitable) was used. The possible applications are based on the suggestions from the focus group discussion. With a score above 4, two classic applications of Blockchain are mentioned: Payment (e.g. of tuition fees) and voting (e.g. of the school or university student representative). Also mentioned with a score just over 4 are the storage of diplomas, year-end transcripts and exams taken from outside school or university (if there is a target-oriented solution for digital identity). Only minimally above the average are areas such as the behavioural grade, the recording of every (even the smallest) test achievement or the class register.

Conclusion & Outlook

In comparison with the study for the European Union by Grech and Camilleri from 2017, several points are confirmed. The knowledge about Blockchain is still in its infancy, open-source solutions are essential for a wide spread and real use of Blockchain technology, privacy settings are important, digital identity such as self sovereign identity or qualified signatures have to be considered, different Blockchain solutions have to be processed by comprehensive educational software solutions and last but not least the possession of one's own data is essential.

The data presented here are part of a larger study [name and funding agency are not mentioned due to the peer review]. In this project different prototypes are developed, such as e-learning systems, learning and test games and identity solutions connected to Blockchain wallets. Further questions from the survey presented here, which have not been considered in this paper, will also be answered. Also the open final question of the survey, which brought further (very good) inputs, will be evaluated in an in-depth paper or on the project website [not mentioned due to peer review]. It is a long way to go that can only be achieved through the joint effort of many individuals, schools, universities and governments involved.

Endnotes

(1) EOS hack on cointelegraph: https://cointelegraph.com/news/hacker-spends-1k-to-win-over-110k-in-eos-betting-game-using-rex
(2) DAO Hack Ethereum explained: https://medium.com/@ogucluturk/the-dao-hack-explained-unfortunate-take-off-of-smart-contracts-2bd8c8db3562
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