20. Blockchain Technology in Education – The Challenge of Interdisciplinary Teaching

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ABSTRACT  Blockchain technology has attracted a great deal of attention since its origins with Bitcoin in 2008. However, the uptake of this new technological paradigm in higher education has so far been slow. This paper presents the state of blockchain technology and cryptocurrency teaching in higher education in Norway. It also discusses the subject following experiences with a completed course on this topic at the Western Norway University of Applied Sciences (WNUAS) and reflects on the challenges of teaching a subject that is highly interdisciplinary in nature.

KEYWORDS  blockchain | cryptocurrencies | economy studies

INTRODUCTION  Every now and again, new ideas, concepts and major breakthroughs in various scientific fields require universities and other higher education institutions to revise their programs and incorporate new-found knowledge. Minor changes are ongoing; teachers update their material and try to incorporate what is new in their respective fields, and textbooks are updated to reflect new scientific findings.

For major discoveries and breakthroughs, new courses and even new programs need to be developed, and this takes more time. Information technology is a field in
which changes occur frequently and the field advances at a rapid pace. Still, the major breakthroughs may occur at intervals of decades. When technological breakthroughs such as the internet and the web do emerge, the curriculum needs to be substantially revised. This takes time, however, and there are several reasons for this.

Universities are expected to provide students with insight into and understanding of fundamental knowledge in the field, at least at the bachelor’s and master’s levels. This knowledge does not change quickly, or very often, but occasionally there will be major discoveries that warrant major revisions and changes to the study programs.

Although the subject of this paper is the challenge of introducing interdisciplinary subjects in higher education, it is motivated by experiences in teaching blockchain technology as part of a study program in economics. Of course, blockchain technology can play an important role in the digital transformation of the universities themselves, for example by providing a more transparent and less costly system for managing academic credentials.

The study of economics in Norway dates back to 1811, when it was taught from the outset following the establishment of the University of Oslo. However, the subject was not a success and it was not until the 1840s that the field comprised more than only a few students and a few courses. It was not until 1905 that a two-year program in economic studies was introduced.

The demand for a more business-oriented economics education rose, and in 1936 Norges Handelshøyskole (The Norwegian School of Economics) was officially opened by His Majesty King Haakon VII in Bergen. Since then, the discipline has grown substantially in importance, and it is fair to say that the economics programs of the past decades have greatly influenced our society.

During the 1970s and 1980s, a range of new university colleges (“distriktshøgskular”) were built in Norway as a result of a political decision based on a proposal from a committee called the “Ottosen-komiteen” (Michelsen & Aamodt, 2007). The goal was to spread higher education across a broader geographical area and also to make a clearer distinction between bachelor-level and master-level students. The university colleges’ mandate was to offer profession-oriented studies for students. From the start, these new university colleges studies in economics and administration quickly became popular and were offered by most, if not all of the institutions (Skoie, 2013).

Though the number of university colleges was greatly cut back at the beginning of the 1990s, there were still more than 40 colleges offering studies in economics and administration as late as 2014. Since then, a wave of new mergers of universities and university colleges has been implemented, and along with a reduction in
decentralized offerings from private universities such as BI (Norwegian Business School), the number of schools offering bachelor programs in economics and business administration is currently 25 (Wiers-Jenssen, Aamot & Næss 2014).

The teaching of economics in higher education can be said to be firmly rooted in the discoveries of the past century, and especially theories developed up until the new millennium. That is not to say that the field has not developed over the last couple of decades, but the fundamental building blocks are firmly rooted in mature theories. The proponents of these theories are often called orthodox economists, suggesting that these are the ones who think in “the right way”.

David Dequech (2007) distinguishes between mainstream economics and orthodox economics by defining mainstream economics as a sociological concept and orthodox economics as a particular set of ideas that define a school of thought. The two concepts are often used interchangeably. He then introduces heterodox economics as the opposite of orthodox economics, where present orthodox economics is strongly influenced by a neoclassical view of economics. The main characteristics of the neoclassical view is the emphasis on rationality and utility maximization, the emphasis on equilibrium, and the neglect of strong kinds of uncertainty (Dequech, 2007).

After the financial crisis in 2007/2008, we have witnessed a growing criticism of the established way of teaching economics (Eliassen, 2016b), or what we might label as mainstream economics, especially at the undergraduate level. This criticism comes mainly from younger economists, but as Dequech (2007) points out, other branches of economics too, especially behavioral economics and evolutionary game theory, are also part of the criticism. Rethinking Economics is an international network of students, academics and professionals who work for curriculum reform in the teaching of economics (Rethinking Economics, n.d.).

Meanwhile, the development of cryptocurrencies as a combination of technology and economics seems mostly to have been ignored by traditional economists. Moreover, younger economists’ criticism of traditional studies of economics is rooted more in the problems of climatic change and of unequal distribution of wealth (e.g. Eliassen, 2016a; Standing, 2017).

Changes in university studies come from both new research and from the demands of working life and the demand from public and private organizations (Wiers-Jenssen et al., 2014). The changes in the establishment and the reduction of economic studies described above is also a reaction to the general demands of master-level graduates. In addition, more universities and university colleges have established business schools that offer master-level education in economics (Wiers-Jenssen et al., 2014).
However, it seems that reactions to new research and technological breakthroughs come slowly and that the universities in general are slow to incorporate new revisions into their programs. This is the overriding hypothesis of this paper. Following the hypothesis, we formulate the following research questions:

**RQ 1**: How do universities and university colleges perceive blockchain technology and cryptocurrencies?

**RQ 2**: How will they deal with this new hybrid of economy and technology in the development of economics curricula?

Following the introduction, this paper continues by explaining the methods used, and then, in section three, provides a brief introduction to blockchain technology and cryptocurrencies. Section four presents the findings from the investigation of blockchain technology in higher education, together with empirical data from teaching a course in blockchain technology and cryptocurrencies, and in section five we discuss the results before drawing our conclusions.

Blockchain technology will, for the most part, be abbreviated BCT in the remainder of this article.

**METHOD**

The data behind this paper was gathered as part of a bachelor’s thesis at the Western Norway University of Applied Sciences, at the Institute of Economics and Administration during the spring semester of 2018. The method behind the thesis was based on a qualitative method including a survey via email of key persons responsible for the studies of economics at the university or university college. A total of 16 institutions were contacted, and 14 responded. The survey was carried out in the period 22nd February – 13th April 2018. All respondents were first contacted by telephone for a brief orientation about the project and in order to seek consent for the survey, which was sent out later.

The initial sample consisted of 25 universities and university colleges. After studying the curricula at the different schools of economics, 16 of them were contacted by telephone after identifying the key persons for the study programs. A survey was then sent to them, and 14 of the 16 institutions responded to the survey. We have also checked the websites of the respondents afterwards and looked for possible courses on blockchain technology.
The validity of the data is considered good since our contacts were mostly persons responsible for the study programs, in addition to the fact that most of the universities answered the survey. The persons responding to the survey were also responsible for the curricula at their institutes and were therefore key persons who were able to answer these questions. Given their roles, they also had good knowledge of the institution’s plans for revising the study program in this field. The reliability of the data is also considered good, given the method. The respondents were first contacted by telephone to prepare them for a follow-up sur-
vey to be sent to them by email. The benefit of combined personal contact and sufficient time to answer the questions, rather than only using one of the methods, is a greater likelihood of more reliable answers. On the negative side, one might argue that a survey will not offer the opportunity to pose follow-up questions, nor will it be possible to consider different physical reactions through body language etc.

The second source of data for this paper is a use case where the course “Bitcoin, blockchain technology and the digital economy” was taught at the Western Norway University of Applied Sciences, at the Institute of Economics and Administration in the fall of 2018. It was offered as an online course attracting people outside the universities as well. One of the authors initiated and taught this course.

**BLOCKCHAIN TECHNOLOGY AND CRYPTOCURRENCIES**

Blockchain technology was first introduced through the white paper “Bitcoin – A Peer-to-Peer Electronic Cash System” by the pseudonymous author(s) Satoshi Nakamoto (2008) and subsequently put to work through the Bitcoin system in early January 2009. Although Bitcoin was based on well-known technology and did not introduce anything new, the way the existing technological components were put together represented an innovation.

Bitcoin marked the start of blockchain technology (BCT) and proved to be a solution to the decades-long problem of how to design digital cash that did not require a third-party to function. Digital cash was nothing new; David Chaum, for example, had already created DigiCash in the 1990s based on his research on blind signatures (Chaum, 1983). However, Chaum’s DigiCash still needed an intermediary in the form of a bank. Later work on developing digital cash followed Chaum and was important for the innovative Bitcoin system (Back, 2002; Dai, 1998; Szabo, 2008).

Bitcoin was a classic innovation in that all the major building blocks were already known. The innovation was the novel way of combining these building blocks. The building blocks consist of public key cryptography (Diffie & Hellman, 1976), hash functions (Hellerman, 1967), digital signatures (Rivest, Shamir & Adleman, 1978), and Merkle trees (Merkle, 1989).

The difficulty in obtaining direct transactions on the Internet without involving a trusted third-party is the problem of avoiding double-spending. In the digital realm, making copies is a very simple matter, and the problem is how to avoid digital cash being copied ad infinitum. The answer Nakamoto provided with Bitcoin was the use of the consensus method “Proof of Work” (PoW) (Dwork &
Naor, 1992). This method requires proof that someone has done an amount of work in order to be able to perform certain tasks. In Bitcoin and most other cryptocurrencies, this translates as solving a mathematical puzzle that requires a great deal of computational power. The mathematical puzzle is a SHA-256 hash operation on the transaction data that is about to be committed and approved for storing on the ever-growing blockchain (A. M. Antonopoulos, 2014).

The only way to solve the puzzle is by brute force – that is, to try every possible combination until a result that meets the requirements is obtained. This is a stochastic process that guarantees randomness (Nakamoto, 2008). The hash value of the previous block in the blockchain is included in the present block, and in this way a tamper-evident chain of transaction data is constructed (Narayanan, Bonneau, Felten, Miller & Goldfeder, 2016).

The economic part of BCT comes from the need to incentivize the actors performing the computationally expensive securing of the network with the mining operations (PoW). The miners performing the PoW are rewarded with newly minted bitcoins after successfully having found a hash value that meets the required difficulty (A. M. Antonopoulos, 2014).

For open, permissionless blockchain systems such as Bitcoin and Ethereum, there needs to be an incentive for the miners who secure the system. This incentive is the built-in cryptocurrency and the reward (in this cryptocurrency) for solving a mathematical puzzle. Contrary to many beliefs, it is not the hash linking of blocks that secures the system, but the massive energy consumption in the proof-of-work consensus method (Böhme, Christin, Edelman & Moore, 2015). The currency thus plays a crucial role in open, permissionless blockchains.

Open, permissionless blockchains have properties that make them possible to develop into information infrastructures (Ølnes & Jansen, 2018). It is useful to look at the different layers of BCT to understand the interplay and interdependences between them. The important function of the currency is what many have problems understanding (A. Antonopoulos, 2016).
We can see from the figure above that the currency is an essential part of an open, permissionless blockchain system. Controlled blockchain systems, on the other hand, will not need a currency: there is no need for incentives since the security rests on the control given to the administrators. It is the combination of currency (economics) and technology that makes open blockchains special from an educational viewpoint. However, controlled blockchains compromise on the decentralization aspect, an aspect that is perhaps the most important one in blockchain technology.
The figure above illustrates the tight integration of different scientific fields, especially the overlap between technology and economics. As stated above, the tight integration of technology and economics is only present in open, permissionless blockchains. However, permissioned blockchains without a currency will probably be of less interest to economists and economics programs at the universities.

The innovation of cryptocurrencies has created a living lab for studying how monies are “born” and how they develop. Despite this, there still seems to be a lack of interest and enthusiasm from leading economists, including teachers, e.g. Krugman (2018), Detrixhe (2017), Montag (2018).

TEACHING BLOCKCHAIN TECHNOLOGY AND CRYPTOCURRENCIES IN HIGHER EDUCATION

This section examines the state of BCT teaching in Norway. Data is retrieved from a bachelor thesis investigating the introduction of BCT and cryptocurrencies in the economics curricula at different universities and university colleges (Knutsen, 2018).

As we have shown in the introduction, the study of economics has changed due to market changes (decreasing number of applicants), new research being incorporated, and political changes. It also shows that such changes take time.

The survey among the representatives from the institutions mentioned in section 2 concentrated on the respondents’ statements concerning cryptocurrencies and BCT in general, and on whether the institution had already incorporated the new field into their study programs or had plans to incorporate it.

The results of the survey showed that only WNUAS had concrete plans to provide a stand-alone course in this field at the time of the survey. The course “Bitcoin, blockchain technology and the digital economy” was offered as an elective for bachelor-level students in business administration, but was also open to anyone interested in the topic, at WNUAS, at other universities, and for people outside of universities. The experiences from teaching the course are presented in the following section.

Molde University College also offered a blockchain-based course in 2018 based on the study of logistics and supply chain management, but it seems they do not offer this course anymore. However, they do offer a PhD course in “Blockchain applications for Supply Chain Management”.

Some of the institutions, such as NHH, said they would teach the subject of cryptocurrencies and BCT within established courses. They also responded that they offered “one specialized course on the topic” (see below). However, we could
not find any stand-alone course by searching the website for the keywords "blockchain", "bitcoin", or "crypto".

Yes, we introduced a master course this fall called ‘FinTech’ (FIE 456) that picks up on Blockchains and Cryptocurrencies. We also discuss Initial Coin Offerings and Smart Contracts in the course.

At the moment we offer one specialized course on the topic, but following discussions with faculty members, we have seen more of these topics being picked up in our standard course offerings, such as banking or even monetary economics.

Cryptocurrencies are a topic that will be part of other major topics like macroeconomics, theories of money, and finance. How big a part it will play within these topics will mostly be up to those responsible for the different topics. (translated from Norwegian)

If bitcoin is accepted as a payment system in many countries, its importance in the global economy will increase. We are awaiting the development, although we have decided to run a new course in this topic this fall. (translated from Norwegian)

Other institutions see this field as interesting and possibly deserving of separate courses; however, for the time being, no courses are planned or provided:

We can see, for instance, that New York University and Columbia University have separate courses in this field, and it might be interesting for us to develop such courses as well. However, this will demand the use of resources that could be used alternatively. For the time being, we do not have concrete plans at our institute. We would also need to collaborate with the Institute of Informatics, which would demand even greater resources. (translated from Norwegian)

This comment is important as it highlights one of the biggest challenges in teaching cryptocurrencies and BCT: the need for an interdisciplinary approach. It is well-known that collaboration across faculties and even institutes can be difficult in most universities. This is the case not only in Norway, but also globally. It will be a major obstacle in the development of high-quality courses in this field because there is a need to understand the phenomenon both from an economic and a technological perspective.
When asking the respondents about their plans for the future, they provided mixed responses. Many institutions see this new phenomenon as a potentially important part of the education in economics in the future, but they are uncertain of how to deal with it.

It is still in an early phase. Cryptocurrencies in general need to stabilize to be used as a means of payment. Blockchains, on the other hand, are exciting and could benefit from more attention in academia and in the study programs. (translated from Norwegian)

I believe that the underlying database technology (Blockchain) shows promise and will eventually be used in different settings. I am more skeptical of the other parts, like the currencies themselves. (translated from Norwegian)

The distinction between BCT and cryptocurrencies is interesting and the quotes above are typical of many people’s notions about the new BCT. The belief is that the currency can easily be avoided and that the interesting part is the BCT itself. This is, however, a misunderstanding of the important part cryptocurrencies play in open, permissionless blockchains. Cryptocurrencies are necessary built-in incentives to secure these types of blockchains (Böhme et al., 2015). However, some institutions also recognize the importance of the currency aspect:

We have several faculty members who are interested in the technology and have started to work with it. That means that we inform ourselves on the issues. We have also started to conduct research on some of the issues, in particular ICOs and the stability aspects of Bitcoin, for example.

Cryptocurrencies and BCT cannot solve all challenges but can perhaps contribute to solve some of them. We think it is important to build competence to be able to draw some conclusions about the areas in which cryptocurrencies and BCT are suitable, and about the areas in which they are not suitable technologies. Above all, this is relevant for our specialized areas of logistics and supply chain management. (translated from Norwegian)

On the question of competence at the institutions in this new and emerging field, the answers are mixed. Some institutions openly admit that they do not have enough competence, and others believe they have some competence in different faculties.
Yes [we have competence in cryptocurrencies and blockchain technologies], at the Faculty of Science and Technology. We collaborate [with them] on teaching, and our students can take courses there. (translated from Norwegian)

[I] do not know for sure, but regarding our university’s strong technological environment in addition to our competence in business and administration [handelshøyskole] I think the answer is yes. (translated from Norwegian)

EXPERIENCES FROM TEACHING A BLOCKCHAIN TECHNOLOGY COURSE

The Western Norway University of Applied Sciences (HVL) offered the course “Bitcoin, blockchain technology and the digital economy” at the Institute of Business and Administration in collaboration with Western Norway Research Institute (Vestlandsforsking). It was offered as an elective course with 7.5 ECTS. The course was open to all – to students at HVL and other universities, and also to people from outside the universities.

Eighty-nine students signed up for the course, which was organized as a distance-learning course (in reality a MOOC). The lectures were streamed and later available as downloadable videos, both on the university’s own platform, but also from YouTube. The exam was also based online so that the students did not have to be physically present in Sogndal, Norway, where the lectures were held.

Half of the students (44) signing up for the course were studying at HVL while the rest came from other universities or from outside higher education. Of the 89 who signed up, 61 completed the exam, and of these, 60 passed the exam.

The course had around 40 hours of lectures and included a compulsory seminar on the topic “What is Money?”. The seminar had invited speakers and was streamed. To be able to complete the course with the final exam, the students had to complete and submit one assignment during the course.

A survey was sent to the students after the exam asking what they thought about the course (Ølnes, 2019). Half of the students (30) responded to this survey. Overall, they were very satisfied with the course and gave it a score of 4.6 points out of 5, with 43% giving it 4 points and 57% giving it 5 points. The only negative comments dealt with technical issues with the streaming. More than 80% of the students followed the course online.

Some of the comments and feedback from the evaluation (all translated from Norwegian):
Part of the reading list, especially the technical parts, was a bit difficult. I don’t have concrete suggestions on how to deal with this, but I have the impression that some of my fellow students share this opinion.

Try to ensure that the technical quality is acceptable. Otherwise a well executed course with high-quality lectures.

This is the first time I have followed a course online and I liked it very much! It’s a good thing to be able to take breaks and go back to the video and watch it over again. I think this should be the standard way [of teaching courses].

This course was a nice introduction [to the topic]. I hope more courses will be provided that follow the model of this course.

A good course on an important topic. HVL should offer this course next year also.

The comments above show that there is interest among economics students in this topic and that there probably is a growing market for this. Furthermore, both feedback from the students and the general impression from teaching the course is that the technology part of the course is difficult for many of the students. The inherent interdisciplinarity of the phenomenon, and the fact that the technology part is challenging, calls for a tighter collaboration between the technology and the economics faculties.

An interdisciplinary approach is not particular to teaching blockchain technology; it is relevant for most subjects. The digitalization of almost all areas of our society will increase the pressure on more collaboration between different sectors, not least in academia. However, blockchain technology is special in that the interdisciplinarity is highly explicit. The blockchain phenomenon is a marriage between technology and economy. Furthermore, governance issues and added features such as smart contracts also bring in governance studies and law. There is reason to believe that blockchain technology will put significant pressure on universities to facilitate further, better interdisciplinary courses. This is also challenging for the teachers since preferably they should have knowledge of both economics and technology in order to provide students with the best teaching.

The comments show that the students regard cryptocurrencies and BCT as an important part of the teaching in business administration and that HVL should build on this and develop it into a more extensive part of the education. However,
experiences in teaching the course also revealed that the economics students, in particular, lack a background for understanding the technological parts of BCT. Another problem is that the structure of courses differs from faculty to faculty. The Faculty of Engineering and Science at WNUAS bases their study program mainly on courses with 10 ECTS, while the Faculty of Business Administration and Social Sciences bases their courses on 7.5 ECTS. This results in a practical barrier for the IT students to take courses offered by another faculty. In this case, the actual course does not fit with the study plan for the IT students, although the topic is highly relevant. One reason for this incompatibility is the merging of different university colleges with different curriculum structures. However, there are now plans for a joint blockchain course in collaboration between the faculties of Technology and Science and of Society and Economy.

**DISCUSSION AND CONCLUSION**

History shows that substantial revisions in study programs do not happen often, and there are good reasons for this. However, when a new technology like blockchain and cryptocurrencies occurs, with a great potential future impact, academic tradition becomes a hindrance to making the necessary changes to study programs.

In the case of blockchain and cryptocurrency’s place in higher education, our investigation shows that at the time of the survey there was only one stand-alone course in blockchain technology among the responding universities. A few universities incorporated the topic into existing courses. However, by incorporating this new combination of technology and economics into existing courses in economics, there is a risk of missing important areas, especially when it comes to the technology. Furthermore, if the technology component is not properly covered or understood, there is a great risk of misunderstanding the phenomenon and arriving at the wrong conclusions.

When incorporating blockchain technology into the traditional economics courses, the genuine interdisciplinary properties of the technology are largely lost. It is perfectly understandable that universities try to embrace new phenomena from their existing platforms, but it hampers development of new courses and will also make necessary interdisciplinary efforts more difficult. Our initial hypothesis about slow uptake is therefore confirmed.

There is a need to combine competence from the fields of both technology and economics when teaching blockchain technology and cryptocurrencies. Some of the respondents acknowledge this but developing joint courses between different
faculties and institutes is easier said than done. There are also other structural barriers between university faculties that create hindrances rather than lead towards an optimal approach.

Going back to our initial research question, we can conclude that most of the Norwegian universities acknowledge blockchain technology as an important new technology that needs to be incorporated into the existing study programs in economics. However, some of the responses may indicate a lack of understanding of the tight and crucial interconnection between the technology and the currency. Without this understanding, it is difficult to design interdisciplinary courses. However, there are also respondents that acknowledge the need for a disciplinary approach to this topic.

Furthermore, the plans for teaching this new technology vary from a modest incorporation into existing courses to establishing stand-alone courses. Some of the universities are also trying to establish joint courses with other faculties in an attempt to bridge technology and economics. As such, the answer to the second research question is that there is no common approach to the challenge of teaching this new topic, and that there seems to be an underestimation of the interdisciplinary challenges that BCT with cryptocurrency brings.

FUTURE OUTLOOK

HVL’s experiment with a separate course in cryptocurrencies and blockchain technology shows not only that there is a demand for education in this field, but also that the students expect and hope for further progression from an introductory course into fully developed study programs. However, there is still a challenge to better integrate the different disciplines in blockchain technology and to remove unnecessary barriers.

It would also be interesting to compare the status in Norway to the status in other countries with respect to blockchain technology teaching and how interdisciplinary challenges are met.

COMMENTS

Svein Ølnes has taught the course “Bitcoin, blockchain technology and the digital economy” at the Western Norway University of Applied Sciences. He also supervised Sondre Johan Knutsen in his bachelor thesis “Cryptocurrencies and Education in Economics – Do We Educate Economists for the Future?” (Kryptovaluuta og økonomiutdanning – Utdanner vi økonomer for fremtidens arbeidsliv?”).
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