TALLINN UNIVERSITY OF TECHNOLOGY

Faculty of Information Technology

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A MOOC for Teaching a MSc-Level Blockchain-Tech Course

Master thesis

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Author’s declaration

I hereby declare that this thesis is based on my own work. All ideas, major views and data from different sources by other authors were only used as reference and/or for research purposes. The thesis has not been submitted for any degree or examination in any other university.

Date

Signature

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Abstract

Blockchain technology and cryptocurrencies are still very much in their infancy in 2015, just as the Internet protocol was back in the mid-90's. This groundbreaking new technology needs to be researched a lot further as it promises to solve many existing sociotechnical problems from a broad range of domains such as finance, commerce, ICT security, system scalability, new business models and e-governance models, and so on.

Currently, there is a significant lack of understanding and education pertaining to blockchain-tech and cryptocurrencies. This results in a loss of opportunities on a public and private level that would otherwise benefit the larger welfare of society. Even when the enormous potential is understood, there exists a great lack of knowledge in the workforce. Many new businesses seek to hire without success people educated in this new emerging field of cryptocurrencies and blockchain-tech as the labour pool simply does not offer such skill sets.

A reason for this skills shortage is that there are lack of educational courses available on blockchain-tech. There are few initiatives, but general focus of this educational programs are Bitcoin as cryptocurrency and less attention is dedicated to Blockchain technology, which is the main technological breakthrough, that contains vast unexplored potential, considering fact that cryptocurrencies are just a first monetary applications on it.

The objective of the master thesis is to develop a MOOC (massive online open course) for teaching MSc-level courses in blockchain and cryptocurrency technology for future integration of the course in academic institutions of Baltic and Caucasus region. The course incorporates best practices of online learning adjusted to the goal of effectively delivering theoretical and practical implications of blockchain technology as the sociotechnical system.

Graduates of the Master program benefit from a broad background, combining courses in finance, management, computer science, and information systems to provide a holistic analysis of blockchain technology and digital currency systems, applications, and services. Thus, the course fosters the creation of a critical mass of educated people with practical competences of creating, developing and deploying blockchain based platforms, products and services;
Additional side effect in case of integration of MSc level Blockchain course in academic

institution's of the Baltic and the Caucasus region will be the stimulation of business activities and boosting economic and ICT scene of this regions; inform and educate government and private sector about many emerging innovative opportunities;

Abbreviations

MOOC - Massive open online courses

Bitcoin – Decentralized digital cash

Blockchain – New type of information technology

P2P – Peer to peer

ICT – Information and communication technologies

DAO – Decentralized autonomous organization

Crypto 2.0 - Application of blockchain technology to the fields other than cryptocurrency

Altcoins - Alternative cryptocurrencies created after the success of Bitcoin

IOT – Internet of things

ORE – open educational resources

LMS – Learning management systems

Moodle - Modular object-oriented dynamic learning environment

STEM - An acronym for Science, Technology, Engineering and Math education.

API - An abbreviation of application program interface, set of frameworks, protocols and unreeling principles for building software application.

PKI - Framework, guideline and set of rules that different systems, vendors and technologies can interpret and use to provide authentication and confidentiality in their data transmissions.

SCORM - Sharable Content Object Reference Model (collection of standards and specifications for online educational technology)

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The thesis is written in English and contains 102 pages of text, 6 chapters, 17 figures.

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1. Introduction

1.1 Thesis motivation

The 21 century is a century of tech renaissance and consequently world society and economies are turning digital every day. Digitalization is pervasive not just in a small set of sectors, everything is gradually penetrated by information technology. One of the main pillars of this revolution is the Internet. Society experiences radical changes that the Internet triggers in all spheres of life as it reshapes our patterns of life, the way how humans do business, interact with each other and etc. Governments, businesses and other institutions are more and more depending on this public good. The Internet democratizes information industries and makes publishing, transferring and accessing of information to near zero marginal cost (Jeremy Rifkin, 2015). New emerging business models that internet is bringing, disrupting existing economical and power structures and carrying exponential changes, which is unpredictable with our linear way of thinking. For existing moment internet is connecting almost half of world population (ITU, 2015), resulting in the uniting of humans around the globe in an unfathomably complex web of relationships. With the internet, realization of vision of the humanity as a technically integrated spices becomes inevitably real.

But back in 1990s when commercial internet was making first steps, there was a lot of criticism it was just a mean to send an email and people was skeptical toward this new type of informational technology. They even do not imagine emergence of Google, Skype, Facebook, Uber, Airbnb and other disruptive models made possible by internet revolution.

In 2008 another event happened. The white paper (Satoshi Nakamoto, 2008) describing peer to peer electronic cash, named Bitcoin was published in cryptography mail list. The white paper outlines the design of cryptocurrency, which is completely decentralized, with no central server or central authority. Author of this paper referred himself as a Satoshi Nakamoto. We know that this name is pseudonym and real person behind Satoshi Nakamoto is unknown, but it really does not matter, because this white paper initiated birth of new groundbreaking technology, which is capable of comprehend almost the same societal impact that Internet have done.

Most important thing in Satoshi Nakamoto's invention is Blockchain technology and the cryptocurrency Bitcoin is just a first application on top of this technology. Majority of venture

capitalists, high level intellectuals from financial, banking and ICT industries working in the field of this new emerging technology are drawing parallel with first days of internet (CNBC, 2014) in terms of technology hype cycle (Gartner's 2014) and venture capital investment, which already has exceeded investment in early days of internet and approaching to one billion dollar for existing moment (Coindesk report Q3, 2015).

The 1960's gave birth to the Internet as a protocol that governed communication rules and regulations for transmitting information over networks and the blockchain technology is doing same, but for transferring of value and when we say value we imply all types of value: currency, any form of tangible or untenable asset, commodity or anything that people put value upon.

For existing moment society is witnessing large movements from big financial institutions, major multinational banks, corporations and governments in direction to explore and find ways of implementing blockchain technology in their ICT systems. Twenty three countries already have their blockchain technology startups (Coindesk report Q3, 2015). California and especially Silicon Valley are in forefront of this revolution in terms of harmonizing and adjusting legislation frameworks. Major developed countries in Europe, Canada, Australia, Singapore, China and others around the world are rigorously researching potential of this technological innovation in order to not to miss opportunities and bring the benefits of this innovation on a public and private level.

Despite the early days of blockchain technology the potential has being grasped, but there is still big gap of the professional workforce, having sufficient expertise. Many businesses are trying to hire without success professionals from blockchain technology as the labour pool simply does not offer such skill sets. Sufficient effort from academic institutions to educate and transfer accumulated knowledge about blockchain technology will foster creation of professional workforce and help to exploit the benefits of this innovation.

This thesis therefore makes an effort to design a MOOC for teaching MSc level blockchain tech courses for academic institutions in Baltic and Caucasus region. MOOC will incorporate best practices of the online education. It will address the important issues about blockchain tech and cryptocurrencies from different perspectives such as finance, management, regulatory frameworks, computer science, information systems, cryptography, ICT security, systems scalability and others. The MSc course will prepare student to become professionals in filed of blockchain technology and equip them with sufficient skills for exploiting employment opportunities in various positions at the

crossroad between finance, management and computer science.

1.2 Theoretical background and Literature overview

This section examines theoretic background and existing literature overview based on the main deliverable of the thesis.

As MOOCs are very recent developments in online learning it is necessary to explore and structure entire body of knowledge in this field including theoretical concepts and practical implications raised from them. Considering above stated author will overview brief history of distance education and summarize existing learning theories and their conceptual directions to create a knowledge base for understanding what are the base contracts of the MOOC.

Then proceeds with exploration of existing practices in MOOC space, their development timeline, types of MOOCs, different elements of the design and actual issues in this space.

Author then continues with analyzing existing educational landscape of the Bitcoin and Blockchain courses and educational resources and summarize their distinctive characteristics to determine main gaps in their educational practices.

Final paragraphs of this chapter will be dedicated to researching methodology and formulation of research question for master thesis.

1.2.1 Learning theories and brief history of distance learning

Shift that educational landscape experiencing now in online education and particularly MOOCs is an effect of radically innovative approach (Hollands, F. M., & Tirthali D. 2014), but origin of this processes has deep roots in history. Different types of media have been used by educators trying improve teaching or learning or just to connect with nontraditional learners in a similar way as MOOCs are doing.

There are many precursor examples of existing distance education technologies thought the history:

Correspondence education in post era. In 1833 music composition was taught through the medium of the post. Radio era, started from 1930 with a radio instructional courses on various topics and television era with tele courses and finally internet era. But early stages of distance education did not have participatory aspects of education as online learning environments, it was just one way of communication.

Learning is a very complicated process, which depends on emotional and environmental conditions. Mental processes running inside the learner are directly correlated with this conditions and are affected by them, resulting in effective or ineffective learning. Mainstream learning theories and their development are based on consideration of this complicated conditions. (Illeris, Knud 2004).

There are four main learning theories, which are evolved through the history and influenced by development of scientific thought in education and technological progress of 21 century. Author will briefly present this theories and overview main differences between them from learning and pedagogical perspective.

In the 1950-1960 behaviorism was dominant learning theory. From 1960 until 1970 cognitivism become mainstream. From 1980 constructivism was developed based on principles of active learning, which emphasizes student engagement in learning process. Finally connectivism theory was evolved based on concepts of knowledge generation by networks and strongly affected by internet development.

Behaviorism as a learning theory purely explores behavior of learner and does not connects it with mental processes, that takes place in learners mind (David C. Leonard, 2002). Knowledge in behaviorism is acquired by modifying learners behavior by means of punishment or reward. Constant adjustment in behavior by stated above means, triggers learning of knowledge, which exists outside of person. Behaviorism learning theory is not learner centric, rather instructor centric. Learner is inactive object with particular level of performance, constantly modified by instructor for obtaining learning objectives. Taking into consideration fact that motivation of each learner differs from each other, reinforcement means is also differs for sustaining the learning process. Feedback from instructor is main source for learner to adjust their behavior for effective learning. Practices of breaking down tasks on small constituent parts and gradually making them more complex, repeating

them as much as possible by realizing drill and practice actions in combination with the means of punishment and reward are the main pedagogical strategies of behaviorism learning theory.

Cognitivism theory (David C. Leonard, 2002) explores how the learner's memory process, stores and retrieves information during the gaining of knowledge. Theory researches main approaches and scenarios, which are used in learning process by learner, how this scenarios are affected by already existing knowledge and learner's unique personality features (Tennyson & Schott, 1997). Based on cognitivism, effectiveness of learning is determined by what information is presented and how it presented. This two factors have further influence on storage and retrieval of knowledge. Learners in comparison with behaviorism theory are active participants in learning process. Instructor acts as a coach and helps to acquire appropriate information processing practices for reaching learning outcomes.

Constructivism views learning as emerging phenomenon from social interactions between learners (David C. Leonard, 2002). Knowledge is generated during the process of interaction and effectiveness of generation is determined by personal features and motivation of the learner. There are two major directions in constructivist learning theory: cognitive and social constructivism. First emphasis how individuality of learner affects learning process. Second emphasizes social aspect of learning, how generation of knowledge is influenced by social interactions. Pedagogical approaches in constructivism considers learners as an active participants and the role of instructor is to help learner in acquiring knowledge by observing learning process and facilitating it, with different strategies and techniques.

Pedagogy in constructivism focus on the presenting problem from wide angle and then let students figure out solutions based on their prior knowledge and motivation. This approach is meaningful for teaching high order thinking skills such as reasoning and problem solving. Constructivism learning theory widely emphasizes utilization of active learning methods for engaging students and giving them possibility to directly interact with a problem or concept.

Finally, connectivism - learning theory of digital age, emerges from the recent development in

online learning influenced by internet revolution. Connectivism considers origination on knowledge from connecting and sharing information between network of individuals. According to connectivism ability to effectively connect right information sources to each other and construct knowledge from them is more important, than knowledge itself (George Siemens, 2014). The notion of crowdsourcing, where groups of individuals are smarter than one person is good example of connectivism. In connectivism learning theory, motivation and readiness of learner are essential factors for acquiring knowledge, inside chaotic networks of information flows. Role of instructor is just to assist and support learner with different strategies and create healthy network of communication and interconnection. It should be admitted that connectivism is relatively new developed concept and scientifically proofed concepts and frameworks are lacking.

1.2.2 MOOCS as a new medium in online education

MOOCs, massive open online courses using internet medium for reaching huge number of audience and are offered by well-known universities of the world for free or small certification cost fee. MOOCs, which emerged from already established structures of e-learning courses are new tools (Carr-Chellman and Duchastel, 2000) in the hands of education providers constructed from different types of digital media, namely videos, electronic text, forums for discussion and collaboration and etc. This digital means are used for accomplishing some particular function, would it be completion of some task, communication with other learners or etc. (Shoemaker, 2010).

MOOC phenomenon is very new, with high expectations that it will penetrate all the aspects of education starting from high education, finishing with vocational education and everything in between. (Worlock and Ricci, 2013). But, yet there is no clear understanding how the potential changes caused by MOOCs will rewrite bigger picture of education. Despite unclear long term future, MOOCs have gained momentum and have continued to attract high volumes of students and attention of different stakeholders.

It is vast area of speculation how different characteristics of the MOOC such as short duration, limited commitment and cost free access might affect our collective perception on what is expected from education and learning experiences. However it is too early to have bold answers. There is no clear proof that MOOCs will have essential effect in education in long term perspective. There are also no agreement what subjects or teaching techniques and frameworks are best for MOOC format. Even though there are many positive expectations that MOOCs are the future of higher education, one of the major MOOC provider the Udacity has no specific connection with higher education instead Udacity offers technical and vocational education oriented on programming and STEM courses.

MOOCs are possible consequence of a flipped classroom (Haber, 2013) pedagogical approach, which means that students are studying particular topic by their own specific pace and methods and then participating in practical activities with professor or instructor in the classroom.

In a previous years, MOOCs have experienced replied changing to adding more features and more courses on various topics. This underlining changes are consolidating MOOCs as a sound alternative in higher education. Different type of challenges as constantly increasing demand of higher education combined with the higher cost of face-to-face learning and the difficulty of accomplishing to a longer-term study program seem to point to the MOOCs as a viable alternative solutions.

1.2.3 Overview of bitcoin and blockchain educational landscape

For existing moment there are few important initiatives in educational landscape of crypto currencies and blockchain technologies (Yessi Bello Perez, Coindesk 2015). This paragraph will review each of them, their basic characteristics in terms of learning directions, certification options and effectiveness.

First and most important player in this field is University on Nicosia (University of Nicosia – MSc in digital currency degree program, 2014), which have lunched first master science degree program. Program's name is MSc in digital currency and it is a first accredited course with possibility to

receive Msc-level degree. Duration of program is eighteen month and student must collect 90 ECTS credits in order to accomplish it. Tuition fee of the program is 11760 euro. Program targets mainly student with programming and financial background. Studies are fully online. Additionally strong side of the program is that one of the lecturer is Andreas Antonopoulos, who is one of the prominent speaker in bitcoin community. By statistical information in 2014 the enrolled 614 students from 76 countries.

Second initiative is coming from Princeton University (Bitcoin and cryptocurrency technologies, Princeton University, 2015), which created MOOC on Cursera platform. Name of the course is “Bitcoin and cryptocurrency technologies”. Course duration is seven weeks. It is free of charge and learner receives course certificate of listener. Course target audience is programers and computer scientists.

Blockchain University (Blockchain University, 2014) also offers eight week intensive courses for computer science students. Main difference with other similar initiatives in this field is that it is strictly oriented on blockchain technologies and more focus on practical issues and project based learning. Course is held in traditional face to face manner (fact can be considered as one of the limitations) and it has tuition fee. One of the strong side of course is guest lectures from the bitcoin and blockchain space.

Stanford universities centre for professional development also going to lunch course named Crypto currencies: "Bitcoin and friends" in autumn of 2015 (Stanford universities centre for professional development, Course named "Bitcoin and friends", 2015). It will have tuition fee and after accomplishment student will receive cyber security graduate certificate.

Another initiative from Stanford University course named “Bitcoin engineering” using 21 Inc. designed bitcoin computer to explore Bitcoin as a protocol and develop bitcoin powered popular internet services (Stanford University course - “Bitcoin engineering”, 2016). Additional interesting factor is that course is constructed around weekly hackathon projects and peoples are studying bitcoin protocol with actually doing staff. One of the lecturer Dr. Srinivasan is a co founder of 21 Inc. and board partner at Andreessen Horowitz, with rich experience in developing innovative business startups. In summary Stanford initiative is more oriented on developing practical skills

regarding usage of Bitcoin protocol for existing Internet services.

MOOC platform Udemy has 18 different courses about bitcoin and alternative currencies (Udemy various courses about bitcoin, 2014-2015). It has various options of study duration. Tuition fees also vary from no fee to 200 dollars. Notable distinctive courses in this platform are Bitcoin for Lawyers and Bitcoin for Accountants offered by Digital currency council.

Khan Academy also offers MOOC named "Bitcoin", creator of the MOOC is Zulfikar Ramzan. It is a small course including no more then 10 videos, but it is very popular among programers and coders (Khan Academy - MOOC named "Bitcoin", 2013).

Digital currency council is offering professional training and certification programs in Digital currency for individuals and organizations (Digital currency council, 2014). There are three different courses with certification options, adjusted for professionals from different backgrounds.
- Digital currency for legal professionals
- Digital currency for financial professionals
- Digital currency for accounting professionals

Training program cost 2995 US dollars and curriculum covers six areas of digital currency:
Origins & technical underpinnings, properties & Monetary Implications, practical use, ecosystem accounting & finance, regulatory & legal. Trainings held in face to face or online environment depending on location.

NYU's Law School and Stern School jointly offering course titled: The law and business of bitcoin and other cryptocurrencies. Course is face to face (NYU - The Law and Business of Bitcoin and Other Cryptocurrencies, 2014). Students are getting 1,5 or 2 credits for the course based on their business or low background. Duration of the course is one semester. The evaluation is a term paper in the end of the course.

There are also some initiatives from Alison platform and LinkedIn's Lynda.com which covers very basics of cryptocurrency use, mining, security, economical issues and possible future development.

In summery specific character of the majority of presented above educational resources is that each of them is oriented on bitcoin and cryptocurrency topic, which is just first monetary application of blockchain technology. Stated above remark is not connected to Blockchain University, but limitation of Blockchain University as author mentions above is a face to face teaching approach, which means no access to the knowledge for the distance learners. So there are two major gaps that is evident in blockchain technology educational environment. First is a lack of exploration of blockchain form socio technical perspective and applications of derivatives of this technology such as smart contract, decentralized autonomous organizations and so on. Notably advanced knowledge in exploration of blockchain technology is offered only by University of Nicosia and Blockchain University. Second is pedagogical methods which are more teacher centered and less oriented on active learning practices, which will give possibility to transfer knowledge to students by taking role of active participants rather, then passive information receivers.

1.3. Research methodology

This paragraph defines research methodology and guidelines for application of this methodology and finally formulation of research questions.

In order to understand fully entire picture of research methodology we should define constituent principals of it, then describe guidelines for research approach that gives more detailed definition on how to apply this methodology to existing body of knowledge.

Finally chapter will end with description of the next constituent components of the thesis structure.

Considering nature of researched topic - designing MOOC for MSc-level master course, which in it's essence is a combination of technological solution and frameworks/models of best online learning principles, it will be appropriate to choose design science as a research methodology. Design science paradigm (Hevner, March, Park & Ram, 2004) described as a pursue to expand boundaries of human and organizational capabilities by developing innovative artifacts that with it's broad meaning represents constructs, models, methods and instantiations.

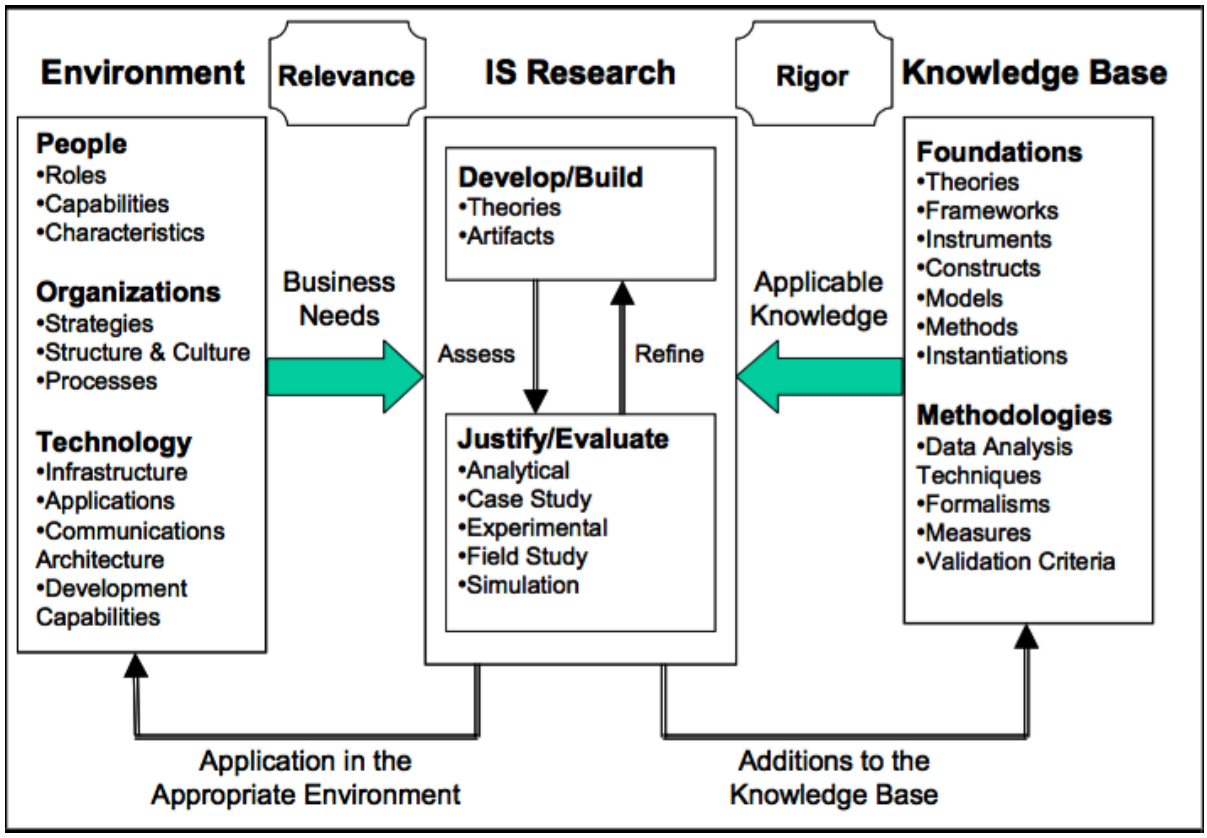

Figure 1. Design-science research framework for the information systems domain (Hevner, March, Park & Ram, 2004).

Figure 1 depicts the core components of information systems research framework.

Left side of figure 1 is a space were the business needs are emerging. This space is composed of people with particular roles, capabilities and characteristics. Organizations with strategies, structure, culture and processes. Final part of this space is technology defined by Infrastructure, Applications, communications architecture and development capabilities. Design science research develops solution by building artifact with relevant respond to the emerging business needs from this space.

Right side is a knowledge base from and through which IS research is accomplished. This space is consisting of foundations and methodologies. Source of the rigor is the application of foundations in the develop/build phase and methodologies in the justify/evaluate phase. Received result of research are calibrated against business needs and cycle is repeated until business needs are fully satisfied with developed artifact.

1.3.1 Design science research guidelines

Below given guidelines gives more described and detailed definition on how to apply research methodology to existing body of knowledge.

Figure 2. Design science research guidelines (Hevner, March, Park & Ram, 2004).

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Guideline 1: Design as an artifact

Thesis deliverable is a MOOC for teaching MSc-level blockchain tech course for educational institutions of Baltic and Caucasus regions (teach globally, accredit locally - model in mind).

Guideline 2: Problem relevance

Currently blockchain technology and crypto currencies are on the early stage of their development. Academic sources of education that will offer interested in this field individuals degree level courses are lacking. General focus of existing educational initiatives are Bitcoin and cryptocurrencies, which accounts for monetary side of the blockchain technology. Lack of

educational programs exploring applications of blockchain technology in different domains rater then finance is missing. On the other hand demand from organizations and businesses is increasing. They are searching new ways for applying blockchain technology in their business models in order to gain efficiency, transparency, high level of automations and transactional capabilities. This situation leads to missed opportunities exploiting the huge innovative potential of this technology in order to benefit larger welfare society. Thesis therefore will try to address this problem with developing MOOC for teaching MSc-level blockchain tech course.

Guideline 3: Design Evaluation

The validity and effectiveness of thesis output are evaluated by the professionals in the higher education field from Tallinn University of Technology, Estonia and Ivane Javaxishvili Tbilisi State University, Georgia.

Guideline 4: Research contributors

The research contribution is a structured multi-media driven learning program for teaching Msc level Blockchain course. Program where the teaching content is an open issue. Thesis will generate minimal required content underlining the knowledge areas and core topics inside this areas. More detailed curriculum generation is subject of future work and can be done by the Universities if they decide to implement curricula in study program. Author will make a proposal of good teaching considering specifics of the Blockchain technology and based on exploration of state of art online education practices.

Guideline 5: Research Rigor

Research rigor will be achieved from detailed analyzes of state of art e-learning models and frameworks for designing and implementing MOOCs. Author will use combination of backward design method for designing education curricula, with innovative framework for MOOC design such as MOOC canvas proposed by Carlos Alario Hoyos and Mar Perez Sanagustin. Additionally author will specify pedagogical strategies based on constructivism and more precisely active and problem based learning.

Guideline 6: Design as a search processed

Design in it's essence is a process of searching for discovery an effective solution to a problem. Solving of the problem can be viewed as utilization of available means to achieve desired results in

a frameworks of laws of given environment (Simon, H.A. 1996). Considering the fact that MOOCs are resent development and there are no specific academically well tested and proved approaches for design frameworks, searching process will invariably involve creativity and innovation and continues evaluation of results against desired goals of the thesis.

Guideline 7: Communication of research

Thesis considered to be serve as a base ground or as a draft document for future implementation and integration in an academic programs of Baltic and Caucasus regions as an independent MSc-level course on blockchain tech and crypto currencies.

1.3.2 Research questions

Taking into consideration the main directions of the Thesis. Following research objective is proposed:

How to rapidly deploy a MOOC for teaching MSc-level blockchain-tech courses?

In order to address this meta question the research objective should be divided on sub objectives and address them consequently. This will lead to formation of research questions. Process of deploying of the course consist of defining different constituent elements of the course and integrate them in two one coherent process to meet defined initial goals. Addressing meta question can be divided in three main steps:

First step is to identify program objectives and outcomes. What is this course intends to achieve and what are the actual outcomes in terms of skills and knowledge that student will acquire after finishing the entire program. Next step, considering backward engineering framework, will be definition of evaluation methodology build on generated objectives and outcomes. Based on above stated, first sub question is formulated as follow:

RQ1: How to specify and develop curriculum objectives and outcomes for the MOOC-based blockchain-tech course?

1. Specify appropriate framework for objective and outcome specification?

2. Define the learning objectives, outcomes? and targeted leaners of the course?

3. What will be the assessment methodologies?

After defining the objectives of the curricula, thesis's continues with exploration of knowledge areas and defining constituent courses of the curricula. Author will specify core content topics for the course based on main elements and constructs of blockchain technology, considering its interdisciplinary nature. After that thesis continues with specifying appropriate pedagogical strategies and integrating, them in the course. This leads to formation of appropriate second research question and subquestions:

RQ2: How to design content and pedagogical approaches for a MOOC?

1. What are the constituent courses of the MOOC and their objectives?
2. What will be the content of courses inside the curriculum map?
3. What pedagogical strategies are used in course? (Active learning and different type of technics)

Final sub question will be how to determine appropriate platform considering all generated results and how to evaluate effectiveness of the designed MOOC?

RQ3: How to define platform and evaluate the effectiveness of MOOC?

1.What will be the platform for deploying the MOOC?
2.What will be the effective evaluation method for MOOC?

Main emphasis will be on the design of the curricula objectives and outcomes and development of the constituent courses with core content. Additionally Limited effort is made on specifying pedagogical strategies for curriculum based on active and problem based learning and evaluation of effectiveness of the course by specifying evaluation framework and conducting thought experiment.

1.4 Description of the thesis structure

The remainder of this thesis is structured as follows:

Chapter 2 gives the overview of Blockchain and cryptocurrency technology form sociotechnical perspective. Also examines MOOC phenomena in the context of online education possibilities and constrains of MOOC as new digital tool. Finally chapter ends with presenting two frameworks: first for designing the MOOCs adapted version of business model canvas by Alario-Hoyos, Mar Perez-Sanagustin, Dave Cormier and Carlos Delgado-Klossand and second backward engineering for curriculum design.

Chapter 3 address the defining the answer on first research question by presenting the desired learning objectives and outcomes, based on backward engineering methodology for curriculum design. Chapter also overview assessment second stage of backward design process.

Chapter 4 combines the outcomes of the chapter 3 and engineers appropriate courses and content for courses, also specifies learning strategies and digital tools for realizing this strategies.

Chapter 5 discusses suitable platform characteristics for the deploying of the MOOC and specifies evaluation criteria for effectiveness of the MOOC.

Chapter 6 draws conclusions based on the findings and discussion of the previous chapters. Also, propositions for the future research is provided.

2. The state of the art.

In chapter 2 author provides an overview of Blockchain technology and its monetary application Bitcoin, which have huge potential to rewrite existing financial and political landscape as we know it. Chapter starts with describing first monetary application of Blockchain technology - Bitcoin form financial and monetary perspective, additionally author presents basic mechanics of bitcoin protocol. After follows Blockchain technology overview with its core capabilities and potential from sociotecnical perspective. Author present Blockchain as a new type of networked database and ways how it can bring efficiency transparency and robustness to the existing segregated information infrastructure in which currently our society operates. Chapter continues with exploration in current landscape of online education and MOOCs description as a new mean of online education. Author characterizes different types of MOOC and deconstructs this new educational tool in constituent element. Next author will define appropriate curriculum design framework, namely backward design. Essence of this framework is to start design process form the specifying objectives and outcomes of the educational program. This method is properly resonates with the objective of the goal of the thesis – to prepare students to become professionals in filed of blockchain technology and equip them with sufficient competencies to meet increasing demand of labor pool in blockchain environment. Finally chapter ends with the additional MOOC development framework - MOOC canvas, which is generated from busyness model canvas. Author will use combination of this two frameworks for development of curriculum for Blockchain tech courses.

2.1 Socio technical implications of cryptocurrencies and blockchain technology.

Phenomenon of crypto Currencies and blockchain technology is radically new for our century and it carries huge potential of reshaping of established social and economical landscape.

Birth of this paradigm was initiated with introduction of bitcoin. It was invented by anonymous developer Satoshi Nakamoto in 2008 as an open source cryptographic protocol for payment system (Satoshi Nakamoto, 2008). From that point technology kickoff and network of users start to grow rapidly, gathering around best intellectual minds from all over the world.

Bitcoin is a first elegant piece of disruptive technology (The economist, 2015). With the invention of bitcoin and cryptocurrencies in general, society now is able to follow and participate in a truly

amazing process of developing independent decentralized, open source, monetary and financial systems, which are totally free from unreliable global financial markets, and political speculations.

Monetary side of cryptocurrency bitcoin examines various interesting characteristics: Bitcoin has fixed supply, which is regulated by the protocol and limited by 21,000,000 bitcoin. Currently the rate of issuance is 25 bitcoin in every 10 minutes. Monetary policy is open and transparent for everyone, because technology is open source. It mean everyone can audit and verify current state of transaction. It also means that everyone can propose changes in protocol and if majority agrees on changes, protocol will be updated. Property of transparency, audibility and free participation of technology strongly underlines its democratic nature.
Bitcoin is very interesting from the perspective of digital medium for exchange. Currency is accepted by society if it has following functions: It is useful medium of exchange, unit of account and store of value and bitcoin perfectly replicates this functions. Additionally its private, decentralized (peer to peer with no centralized authority who can control it), with transparent and fixed monetary policy. This features of cryptocurrency creates very interesting reality and when this reality goes mainstream society will face the question of reimagining existing financial architecture of the world.

But monetary side of bitcoin is only the top of the iceberg and underlying technology blockchain is huge technological breakthrough that could be of enormous importance with it's socio technical nature (The wall street journal, 2015). Blockchain technology represents public transaction record ledger, which provides integrity of transactions without relying on central authority. It enables to achieve consensus in an anonymous network with eliminating problem of trust between users of the network. Design of protocol incentives participant to play honestly and rewards those who do so with bitcoins. At the same time dishonest players are easily traceable, for the reason that technology is open source and all their behavior is tremendously inefficient in terms of financial investment. Additionally because of the programmability feature you can program transactions to represent anything according to your need, would it be bitcoin, financial asset, physical asset, access certificate to some database, desired business logic or something else. Simply speaking blockchain is a distributed, programmable and non reversible value transactional or transfer system with the history of all transaction and no one have ability to manipulate or delete any record, until all members of the network do not agree to do so (The Economist, 2015).

Lets go all the way back and discuss process in which our society currently works, which is constrained essentially with SQL databases. Inside of every large organization including governments there is installed usually oracle database and anything you could represent inside of current scheme of database is real and anything you cannot represent, wind up bogged together on the bunch of spreadsheets that are not with in institutional reality, but rather grown up in the corners. They are understood as been kind of craft databases, that grow inside of organization to represent things that main data core can not. So the paradigm of big centralized organizations, with huge server factories in which all institutional wisdom of organization is trying to migrate, is a standard model for basically entire western civilization and not only western civilization it is a structure of economy. You see that across all institutions any size and anywhere in the world.

Blockchains are innovation at roughly the same level of generality as invention of SQL database (Viany Gupta, 2015). It is a fundamental computing technology that over the course of dozens of years will become ubiquitous in some form for all computing systems. You have file, you have database, and now you have a blockchain and you solve the problem using a file database and blockchain depending on suitability of problem for that particular storage or cooperation technology. This is something that fits wright along side of core computing architecture that our civilization runs on. It is a parallel reimagining of how we use, store and cooperate at the data level individually and between organizations and it goes down to the lowest level of computer stack.
Blockchain allowed things which are illegible and impossible inside of SQL database model to exist and specifically there are collaborations, which are impossible in SQL database model to exist. So when you got single big database in the heart of your organization, which stores all truth and all wisdom you are very reluctant toward other people to touch that database. You emit truth from the database and it goes through whole bunch of hands and then you give it to another organization and it goes again through another hand and they put it to their database and collaboration is very indirect long and complicated, because nobody wants anybody else near their database.

So we work in a society that is formed of huge database backed institutions that communicate with each other through very inefficient and very indirect means and it produces balkanization of power of big monolith that generally speaking, do not cooperate well and are hostile to use because they are just paranoid for their data. It is reality of existing economical structure on the level of databases

(Vinay Gupta, 2015).

All this is driven by technical limitations of SQL database. If the SQL database had been a technology that was designed around cooperation between organizations and taking into consideration constant exponential change we would have completely different macro social structure, because it would be much more efficient to cooperate, share and change things. Instead SQL database technology which is at the heard of our civilization is bad at cooperation, sharing and changing things. And so we are locked in a social structure by the underline nature of the technology that our society lives in.

With the advance on network and network technologies, issue of decentralization and interconnection become more actual. It suddenly enables migration of power into edges and economical model get stuck, because institutions were working with technologies that does not allowed this migration to exist. That is why big centralized database driven organizations were technically locked in SQL based database technology.

This issue is really fundamental it is about techno social systems the technology enables society and society selects technology. So, existing situation can be seen as a tension between two generation of technology the old generation of technology which is SQL database and new generation of technology which is network. The network has a set of properties that support decentralized improvised rapidly changing, fluid kinds of societies.

Database culture one big centralized database and all your data goes into the database, someone control and protect the database on your behalf and nothing will ever change.
Network culture we have got a whole bunch of tools, we constantly change tools we use, data lives outside of individual tool, because you what to be ability to migrate, things are constantly changed.

Blockchain is essentially networked programmable database it solves many of the same problems, that you solve with SQL database but is solves it in a way that entirely about the network, rather old kind of bureaucratic centralized data farm. Reason why blockchain is enables agile and fluid collaboration opportunities, is that everybody shares same database and its standardized so everyone form the beginning are talking in a same language, in comparison with existing balkanized reality of

organizational database structure. Additionally it is design to be non repudiative, it means, ones you write something on blockchain you can not change it. Rather have this different schemes that every organizations have for representing their reality, blockchain creates shared, standardized view on reality that can not be modified, reversed or change.

Notion of Smart contracts powered by Blockchain

Right now software exists inside of given organization or inside of given individual's property, even if its running in the cloud its running in a pice of cloud that you rent therefore it is your cloud. The result is that software is always has the agency of the person that is paying for software to exist (agency from technical economic sense) its my software, its your software, its there software.

Another result to large degree software doesn't change the trust architecture that exists in the world. My software is not so different from my staff or my book or my industrial machine or what it happens to be.

Once you add the smart contract you have software which is exist in a space between us (and same time remains yours), so the software in some sense relational, it exists inside of the node, it exists inside of network and that is very interesting because its generates new architecture of trust and new architecture of thrust is powerful shift, last time somebody invent really fundamentally new trust architecture the output was capitalism - joint stock corporation was new way of handling trust, limited liability company was new way of handling trust and what came out of it was enormous change. In a high level of abstractions smart contracts can be the next stage of capitalism development.

2.2 MOOCs and current landscape of online education

MOOCs is an evident example how the digital era, namely the Internet and information technologies are influencing on old ways of well established educational principles and existing institutions, which are the followers of these principles. Appearance of MOOC phenomena has

caused fair disputes in academic circles (MIT, Justin Pope, 2014). Evidently it is a way to reach the entire world and create opportunity of education for everyone to unprecedented scale, but it could be also a case when education becoming shallow due to unclear standards and ability to open access of new stockholders with not necessary solid experience of the given filed. So for existing moment question of scale and quality is in mainstream in MOOC environment.

We do not know what future development of technology holds, but tendency is more inclined toward creating learning which will be dynamic and adjusted to individual scenarios, when the content of the course will be adapted to speed and learning patterns of person or group of students and engagement and excitement of student will be measured by analytical data of hard beating, eyes tracking and so on (James E. Willis, 2014). All this will allow us to draw detailed picture of learning process of each individual and create well automated full cycle of technological process of education in real time. Technologies can be exploited to the extend of futuristic statement by Ray Kurzweil that: in future we will put our neocortex in a cloud. But lets back in present and continue with early stage of MOOC development.

The term MOOC was coned in 2008, with the starting of course "Conectivism and connective knowledge" offered by Dave Cormier in university of Manitoba. Course attracted 2300 students who took it online, beside the 23 students who participated in old face to face way. In autumn 2011 course of Stanford professor Sebastian Thrun, which was about artificial intelligent attracted 160 thousand students. This was a tipping point and everyone in academic community understood the potential of this technology.

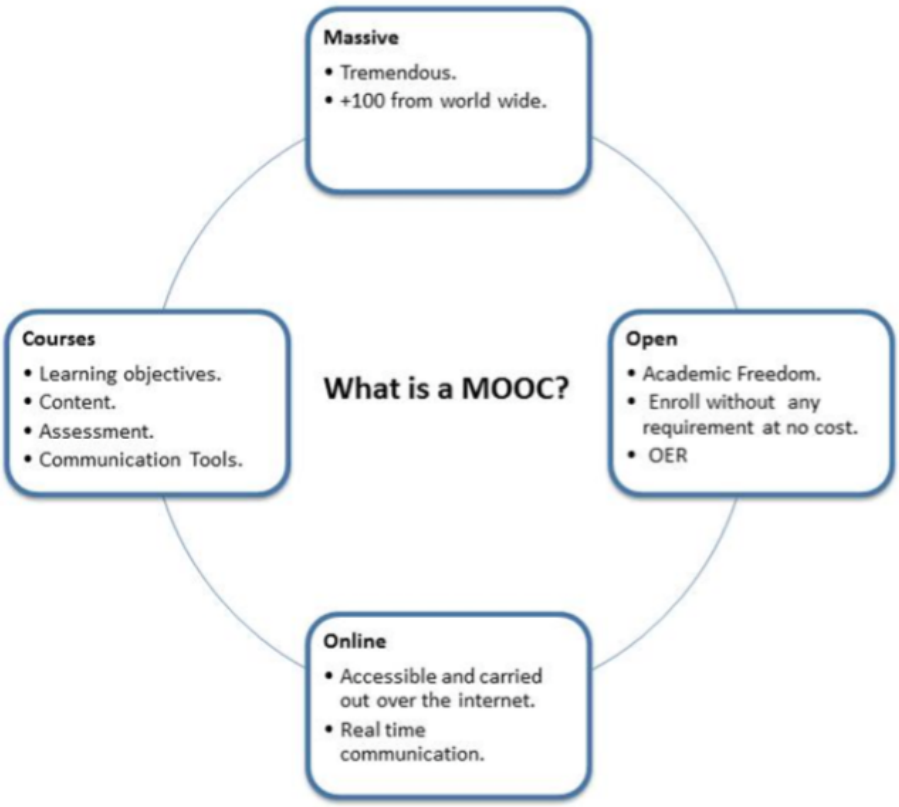

Figure 3. Definition of MOOC abbreviation

Meaning of MOOC is defined as massive open online course.

Massive is related to it's scale and capacity of obtaining large amount of data about participants performance and their activities. Scale of online participants vary from few thousands to few hundred. This kind of numbers are practically not feasible to achieve with the old classical way of face to face based classrooms.

Open is related to access factor. Everyone with internet connection and computer can participate. There are some courses that have small fees to pay, but monetization option of this courses are targeted on the audience eager to receive official credentials issued from the course designer university. Sometimes open is also associated to content of the course based on open educational resources, which is open for downloading and sharing.

Online, this term is most clear for understanding and it reflects online nature of the course.

Course underlines the notion that MOOC is bounded by time. So it should have some structure, which should be restricted with some particular time period.

There are variety of MOOCs with different flavors, but generally they are grouped in two major categories xMOOCs and cMOOC defined by Stephen Downes. CMOOCs are based more on connectivist learning theory principles (George Siemens, 2014), emphasizing the networked and more chaotic nature of knowledge creation. Peer to peer interaction patterns are more dominant, community formation, openness, autonomy, diversity and interaction is more emphasized and role of lecturer is not to be in the center of learning, but act more as a coach of facilitator. XMOOCs are based more on behaviorism and constructivism learning theory principles. They are more oriented on scale and number of participant. Learning style in comparison with cMOOCs is more traditional, which means that they practice online replicate version of classical auditorial learning with lecturer in center, with predefined learning materials and learning space constrained by learning platform.

Figure 4, exhibits additional differentiation characteristics of above mentioned MOOCs.

cMOOC & xMOOC

	cMOOC	xMOOC
Synchronization	At own pace	By teacher
Certification	University, firm or badge. Not necessary	University, firm and badges
Assessment	Among pairs	University & firm
Teacher attitude	Facilitator	Owner of knowledge
Student attitude	Autonomous, sociability	Flipped learning
Student objective	Self enrichment	Promotion

Figure 4. CMOOC and XMOOC comparison

Additionally it should be mentioned that for higher education institutions, the decision about how to design the MOOC to offer massive number of students, particular courses is more related with xMOOCs, which are content based, with limited interaction space constrained by platform (Gaebel, 2013). Compared with communication based cMOOCs were interaction can happened outside the platform (Yousef et al., 2014).

Currently largest MOOC provider platforms are Coursera, edX, Udacity (which are more xMOOC style), Udemy and Khan academy. For creation of edX (collaborative project of MIT and Harvard university) 60 million dollars was invested, then comes Coursera with 22 million and finally Udacity with 16 million. Figure 3, reflects the development timeline of MOOCs from different providers. Stated above facts underlines high interest of venture capital in exploring innovative ways to globalize education field.
From the top 100 universities form Times higher education ranking 59 already have implemented their MOOC using existing platforms.

From the view point of universities MOOCs are very effective marketing tool to showcase themselves and save cost of developing new programs, once university implement MOOC then they can use it for hundred of thousand of students, with no more significant expenses. Finally after technology will be sophisticated it can be more clear what are the sound models for miniaturization.

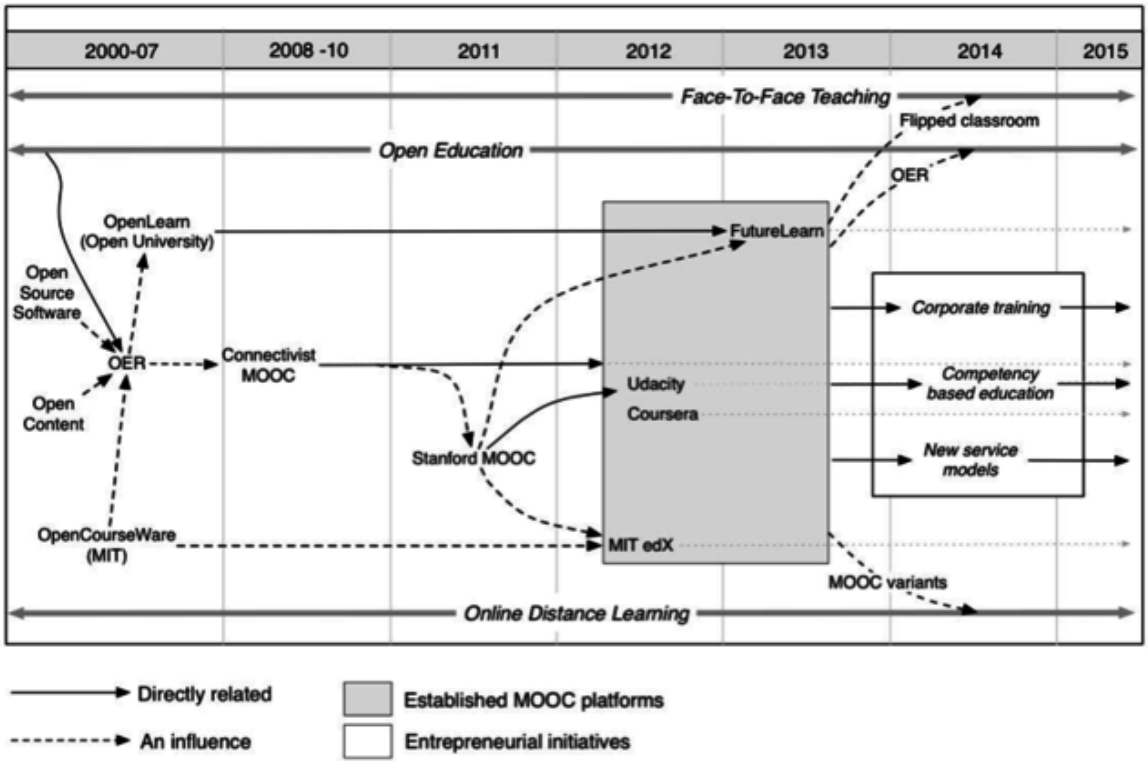

Figure 5. Timeline of MOOC development

Figure 5 represent influence of MOOCs on educational landscape considering higher education with traditional physical classrooms, open education and online distance education. It also shows possible trends emerged form MOOC platforms in training and education such as corporate training, competency based education and possible new service models.

2.3 Conceptual frameworks MOOC development and curricula design

In this paragraph author will examine two design frameworks for MOOC development and curricula design. As the MOOCs are new in educational field there are no clear pathways or standards for design. Each institution or educational provider is creating their own methods build upon on previous learning experience and available resources.

First author will discuss MOOC canvas model, which is utility to narrow forces on particular issues necessary for design process. It gives the range of matters to layout thinking directions, considering

wide spectrum of issues form financial and organizational side to actual pedagogical perspective. Secondly paragraph continues, with backward design framework for specifying goals, which will be the bases to generate appropriate assessment methodologies and pedagogical practices.

2.3.1 MOOC Canvas adapted version from business model canvas

Regardless of huge popularization in MOOC adoption we should underline mentioned above statement that: there are no clearly defined pathways for MOOCs design. There is common understanding of x and c MOOC classification but this is too general and each institution is using their own specific vision to address design issue. Additionally majority of frameworks are reflecting pedagogical perspective and do not take into consideration technological, logistical and financial aspects of design (McAuley et al. 2010).

Another interesting proposition for MOOC design comes from Carlos Alario-Hoyos, Mar Perez-Sanagustin, Dave Cormier and Carlos Delgado-Kloss (Journal of Universal Computer Science, vol. 20, no. 1, 2014). In their paper they offer conceptual framework of MOOC canvas, which is adapted version of Business model canvas. Canvas considers eleven points which are interconnected with each other to guide educators throughout the design process. This eleven points are grouped in two main categories: available resource categories and design decision categories. Available resource category reflects issues of logistical, pedagogical, technological and financial areas. Resources category reflects resources of teaching personal such as Human and intellectual resources equipment and platform for running the MOOC. Financial resources are considered as a necessary source for available resource category and did not have additional column in canvas. The main determining part on MOOC design is the design decisions category although available resources indirectly have influence on design process. Bellow author will present MOOC canvas and will go through each graph and will flash out each associated questions with them. This framework will be useful for following paragraph for formation the research question.

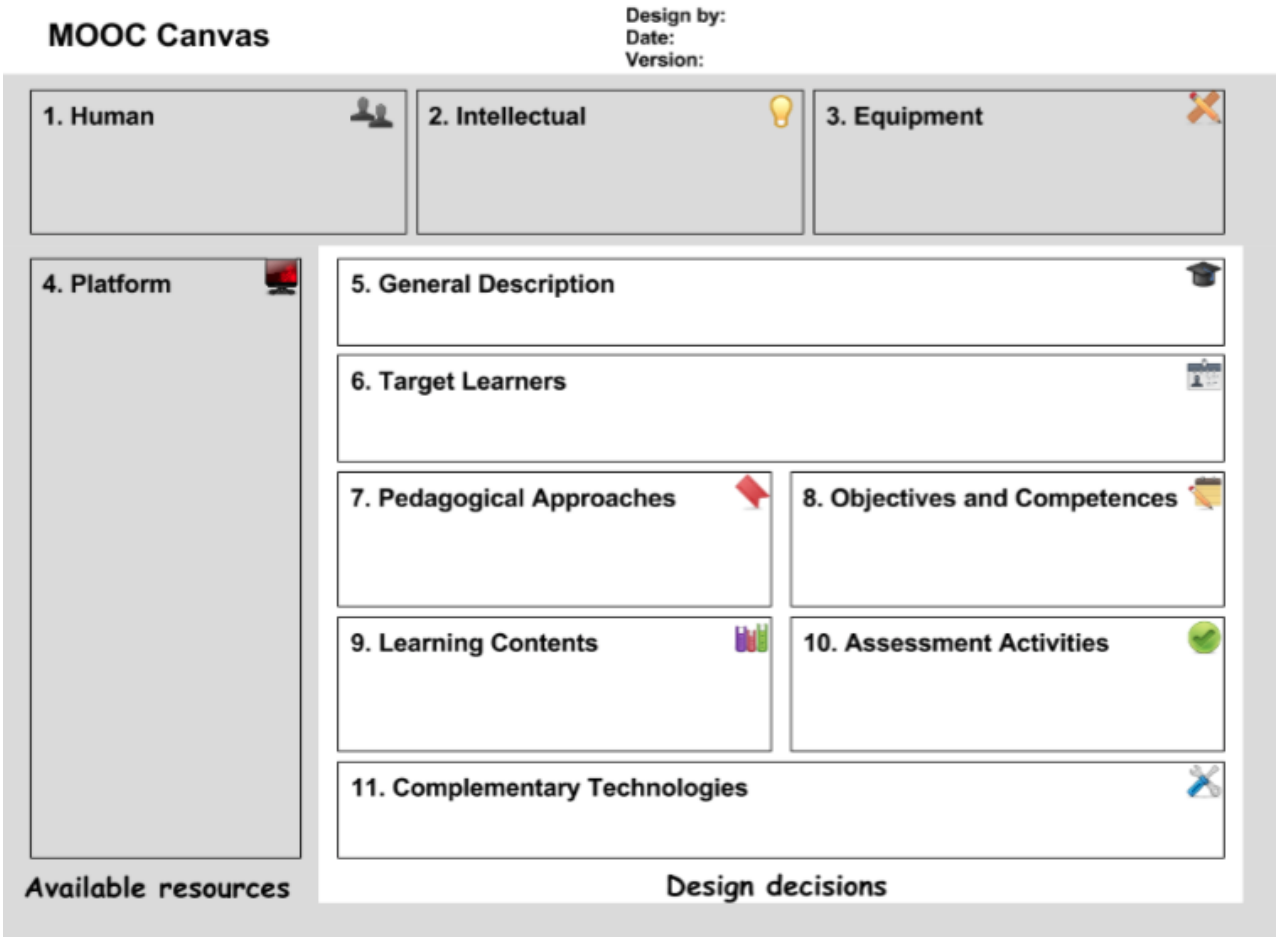

Figure 7. MOOC Canvas. Available resource category (1-4) and Design decisions category (5-11).

Issues in the available reassures category:

1. **Human** - Affected issues 5, 7, 9, 10 and 11

For set up MOOC approximately it takes 100 hours before implementing and 10 hours per week during implementing (Kolowich, 2013), and this approximation is valid for standard 8 week course. Appropriate questions are:

(1.1) What human resources (number of lecturers or assistants are available) do course stakeholders have for running the MOOC?

(1.2) Do you consider hiring someone to assit you during the operation of the MOOC?

2. **Intellectual** - Affected issues 5, 6 and 9

This category is responsible for copy write issues of course content. Are they free to use or for

obtaining them some additional consent is needed from authors.

Appropriate questions are:

(2.1) What intellectual resources (learning materials, open educational resources, videos, recorded conversation) do you have for starting the MOOC?

(2.2) Do you have the financial means to spend on additional intellectual resources?

3. **Equipment** - Affected issues 9

Category is related to software and hardware that is necessary for creating, recording and editing materials such as videos, podcasts and other content.

Appropriate questions are:

(3.1) Do you have hardware resources for creating educational content for MOOC (recording studios, cameras…)?

(3.2) Do you have software resources for creating educational content for MOOC (licenses for video recording and editing software)?

4. **Platform** - Affected issues 7 (strongly constrained by 9, 10 and 11)

Platform is one of the main issue in design process and have high impact on other categories. Generally it should be known in beforehand, because all the learning content and interactions are deployed there, so choosing the appropriate functional solution is essential.

Appropriate questions are:

(4.1) What kind of file formats and assessment methods (peer review, multiple choice) are supported by existing platform?

(4.3) what type of social tools can platform support?

Issues in the available design decisions category:

5. General Description - Affected issues 6,7 and 8

The understanding of this category is pretty straightforward. Additional comment will be that approximate duration of the course should be 8 weeks longer courses are getting boring for students and they are loosing motivation.

Appropriate questions are:

(5.1) What is the title, duration and field of MOOC?

6. Target Learners - Affected issues 7 and 8

Designers of the course should have in mind what who will be the future students. To consider teaching language or possibilities of translation on different languages, literacy and educational background of students, how many hours they can dedicate to learning and main question what is their motivation.

Appropriate questions are:

(6.1) what are the countries were students come from?

(6.2) What is the educational background of students?

(6.3) What are the professional experience of students?

(6.4) What is the motivation of students for enrolling in MOOC?

7. Pedagogical Approaches - Affected issues 8,9,10 and 11

This is one of the important category in MOOC design and influences on course structure and curriculum. What approaches should be used and on what stages: conectivism, active learning, project based learning, case studies, collaborative learning and others

Appropriate questions are:

(7.1) What teaching methods do you consider to apply to MOOC?

8. Objectives and competences - Affected issues 9 and 10

This category is firmly tight with learning content and assessment of students.

Appropriate questions are:

(8.1) What are the learning objectives of the MOOC?

(8.2) What type of skills and competencies student should gain after accomplishing the MOOC?

9. Learning Contents - Affected issues 9 and 10

Majority of MOOCs have video lectures which is recommended to be no more then 10 minutes accompanied with build in questions.

Appropriate questions are:

(9.1) What is a structure of learning contents?

(9.2) What type of file formats learning contents have?

10. Assessment Activities - Affected issues 11

This category defines assessment issues, formative assessment is good to stimulate reflection and enhance learners attainment. Also designers should consider platform capability with specific type of assessment.

Appropriate questions are:

(10.1) What type of formative assessment you are going to apply for MOOC?

(10.2) What type of summative assessment you are going to apply for MOOC?

(10.3) does existing platform supports this assessment?

11. Complementary Technologies

Complimentary technologies are related to adding more functionality to MOOC in case it is not built in platform. They are more appropriate for c types of MOOCs.

Appropriate questions are:

(11.2) What type of additional technologies you will use if any for delivering contents or for easement?

(11.4)What type of complimentary technologies you will use to encourage discussion and engagement among students?

It should be mentioned that MOOC canvas is an initial approach for decreasing the complexity of MOOC creation and it is not a standard way, only attempt to frame some design elements in visually more understandable way.

2.3.2 Backward design principles

Backward design is one of the well established frameworks for designing curriculum in education. Main principle of Backward design framework is to formulate the end goals of the curriculum and skills and knowledge, that student should acquire after the graduation of the curriculum. After specifying goals and desired outcomes, instructional designer adjusts assessment method to for validating this outcomes and also specifies appropriate instructional methods and strategies to transfer knowledge and skill set for obtaining end goals.

Bellow author specifies each stage of backward design according to Grant Wiggins and Jay

McTighe book: “Understanding By Design” 2nd Expanded Edition, (2011).

1. Identify desired results (knowledge and skills)

First stage identifies desired outcomes of the course: What will be students knowledge (different theories, concepts and principles) and understanding of particular education domain and how he can apply this knowledge to solve particular problems (practical skills and competences).

2. Specify assessment method based on which obtaining of the end goals of the curriculum can be evaluated. Assessment methods should be clear and well structured and most important, it should fully capable of capturing occurred learning inside curriculum.

3. Final stage is to specify the instructional activities that facilitate achievement of desired goals of curricula.

On this stage educational instructor designs teaching practices and Consider teaching methods, arrangement of interactions and content of the curricula.

Backward design have different approach to curriculum design in comparison with traditional design. Focusing on goals creates better assurance of materials to be learn and learning process to be employed. Backward design is compressed version of ADDIE model (Ed Forest, 2014), which is an effective framework in instructional design.

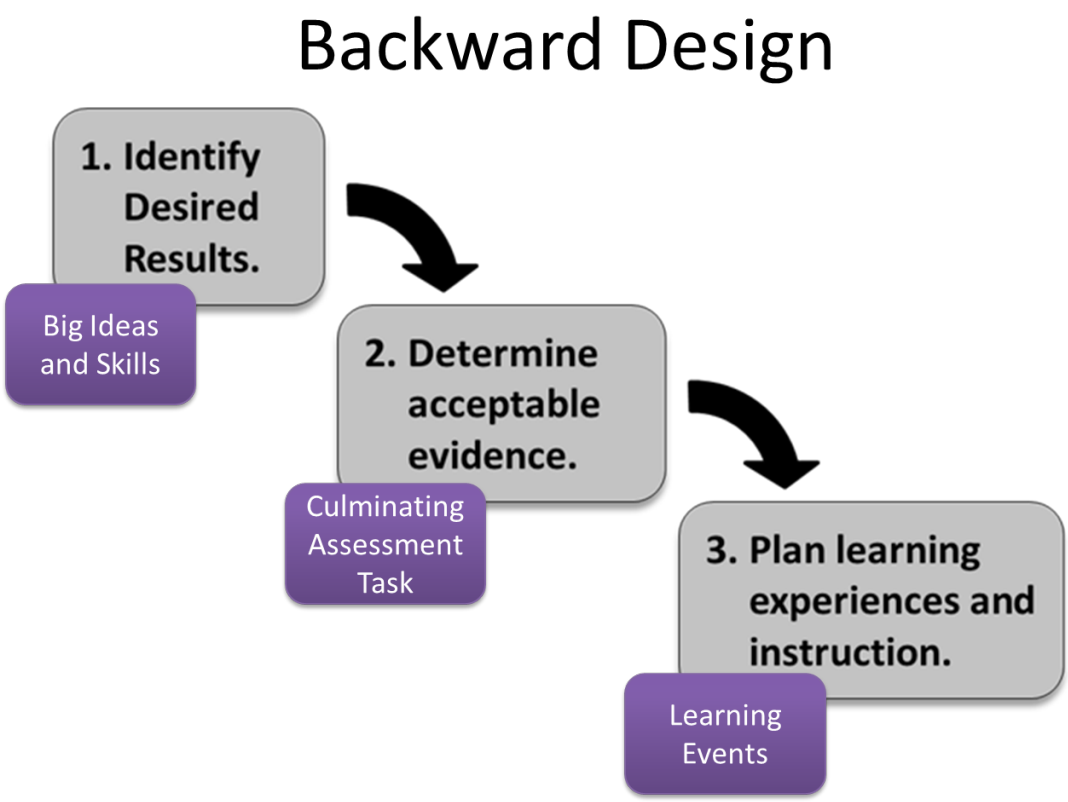

Figure 6. Three stages of Backward design.

Assessment stage in the process of Backward Design

First stage as we state above is a stage of goal and outcome engineering it is followed by second, assessment stage. Assessment stage ensures integrity of the developed goals and serves as a bridge to third stage of determining instructional practices and methods for achieving educational outcomes. Assessment practices will be the combination of formative and summative assessment

3. Developing course curricula

The first step in developing MOOCs curricula is to consider the initial motivation of the thesis, particularly preparing skillful professionals to address scarcity of labor pool existing in blockchain technology and cryptocurrency field. Logically first initial thinking direction is to consider what type of skills and knowledge MOOC should transfer to learning audience.

The cryptocurrencies and blockchain technology encompass many interrelated academic disciplines from finance and computers science, sociology, business administration, legal studies and so on. The goal of this chapter is to identify and specify learning outcomes of future students and based on this outcomes, with reverse engineering attitude come up with the effective courses and content.

There for the identified goal will be addressed with first research question:

RQ1: How to specify and develop curriculum objectives and outcomes for the MOOC-based blockchain-tech course?

1. Specify appropriate framework for objective and outcome specification?

2. Define the learning objectives, outcomes? and targeted leaners of the course?

3. What will be the assessment methodologies?

Chapter 3.1 will define Blooms taxonomy which is a useful tool for arrange the complexity of learning objectives and outcomes. the expected outcomes and target audience of the course will be presented in chapter 3.2

3.1 Bloom's Taxonomy framework for curriculum objectives development

Taxonomy was developed by Benjamin Bloom in 1956. Bloom's taxonomy represents list of objectives and skills that educational instructors are aiming to achieve during the learning process. Taxonomy is a complex framework, used to connect learning objectives, learning techniques and assessment to achieve this objectives (Anderson, Lorin W.; Krathwohl, David R., 2001). Author will examine cognitive domain of Bloom's taxonomy, because of it’s wide popularity and usage in designing and implementing various educational programs. Cognitive domain of taxonomy is consist form six levels, this six levels also classified in two abstract categories: high level thinking and low level thinking.

Bloom’s taxonomy have a hierarchical nature. Learning is starts from low level knowledge and skills and gradually it advances to higher level knowledge. Figure 8 presents how knowledge and skill are advanced from low level to high level.

Bloom’s Revised Taxonomy	
Lower-Order	1. *Remembering:* Retrieving, recognizing, and recalling relevant knowledge from long-term memory
	2. *Understanding:* Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining
	3. *Applying:* Carrying out or using a procedure
Higher-Order	4. *Analyzing:* Breaking material into constituent parts, determining how the parts relate to one another and to an overall purpose through differentiating, organizing, and attributing
	5. *Evaluating:* Making judgments based on criteria and standards through checking and critiquing
	6. *Creating:* Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing

Figure 8. Bloom's Taxonomy

Bloom’s taxonomy and learning objectives:

Each particular skill in bloom’s taxonomy is connected to to the action verb that reflects what type of instructional practices can be used to achieve this skill. Figure 9 present verb tables corresponding to skills in Bloom’s taxonomy

Bloom's Level	Key Verbs (keywords)
Creating	design, formulate, build, invent, create, compose, generate, derive, modify, develop.
Evaluating	choose, support, relate, determine, defend, judge, grade, compare, contrast, argue, justify, support, convince, select, evaluate.
Analyzing	classify, break down, categorize, analyze, diagram, illustrate, criticize, simplify, associate.
Applying	calculate, predict, apply, solve, illustrate, use, demonstrate, determine, model, perform, present.
Understanding	describe, explain, paraphrase, restate, give original examples of, summarize, contrast,interpret, discuss.
Remembering	list, recite, outline, define, name, match, quote, recall, identify, label, recognize.

Figure 9. Verb tables associated with Bloom's Taxonomy

Verb tables are clear and simple way for developing instructional strategies for achieving particular competencies and skills.

3.1.1 Defining learning objectives, outcomes and target learners

Learning outcomes are the initial considerable issues on top of which the rest of design process can be build. Sociotechnical domain of blockchain technology considers many interconnected learning objectives from different disciplines such as finance, commerce, computer science, ICT, cryptography, distributed systems, cyber security, systems scalability, new innovative business models and startup culture and so on.

Purpose of a course is to produce Master level graduates who can apply sound scientific methods for independently developed inventions. Program produces two types of graduate with the competences, in financial technology and computer science. Additionally, students interesting in farther research can continues their research in their Doctoral works. In future program can be adapted on nano degree programs for legal professionals, accounting and audit professionals and etc.

Objectives of the Blockchain tech course is to prepare professionals with high competences benefiting from a broad background, combining courses in finance, management, computer science, and information systems, provide a holistic analysis of blockchain technology and digital currency systems, applications, and services. Professionals who can apply sound scientific methods for independently developing inventions.

Equip future students with sufficient skills and competencies for pursuing their career goals: would it be become entrepreneurs and start their own companies, or continues as a financial professionals, software developers or consultants, if they prefer corporate life.

Develop solid understanding of professional and ethical responsibility.

Develop skills and knowledge for abstracting essential structure, recognizing sources of uncertainty, and applying appropriate state of art models, technical tools from blockchain environment to develop different solutions for existing financial and IT applications.

Upon successful completion of this program, students should be able to:

Define money and it's supplying mechanisms. Develop solid knowledge and ability of comparison of existing money transfer systems and international financial markets to mainstream digital currencies and their alternatives.

Understand and master theoretical foundations on currencies, banking, the character of central banks and their monetary policy. Define possible implications of blockchain technology and digital currencies upon them.

Analyze and point out challenges, possibilities and risks of blockchain technologies and digital currencies and formulate business proposals and design systems and services that address them.

Understand and put in practice strategies of adoption and marketing of Blockchain technology

Gain clear understanding of smart contracting and decentralized autonomous organizations in wider sociotechnical perspective. Acquire firm understanding of smart contracts and role of this technology in cross organizational collaboration automation. Design, implement, and evaluate smart contract based systems, process, components, or software across different industries.

Conceptualize, prototype and implement decentralized autonomies organizations.

Understand and apply theoretical and practical knowledge of Blockchain technologies and smart contracts to design innovative financial and e-government platforms and services that supplement and extend the existing crypto 2.0 ecosystem.

Be able to apply mathematical foundations, algorithmic principles, and computer science theory in the modeling and design of different kind consensus algorithms for blockchain technology based systems. Tackle the problems with security and scalability.

Master knowledge of application of blockchain technologies, smart contracts and crypto currencies considering different regulatory frameworks. Offer advice and consultation on various regulatory

environments such as commerce, payments, accounting, Software and so on.

Gain ability to analyze the state of art in blockchain technologies and apply in practice this knowledge to capture new emerging business models, address problems on individual and business level for benefits of larger society.

Targeted audience is divided in two main categories, which are individuals with finance and computer science background. Focusing geographical area for implementing MOOC is a Baltic and Caucasus region. But as course will have MOOC format so, it will be offered world wide. Teaching language will be English. In case of demand from other institutions and faculties some courses form curriculum can be taught separately integrated in different faculty's curriculums.

3.1.2 Defining assessment methodologies

Before the considering issues with assessment techniques in MOOC first step is to define notion of summative and formative assessment (Hanna, G. S., & Dettmer, P. A. 2004):

Formative assessment is defined as wide variations of techniques that teachers use during the process of learning to observe and evaluate student advancement, their comprehension and learning requirements, so it is more like snapshot of students knowledge for particular time.

Summative assessment is defined as evaluation of student after the finishing the course or subject focusing on final outcomes sum of the knowledge that student acquired.

Formative assessment is more flexible and allows to integrate assessment into the pedagogical practice itself to measure progress of learning during the process. Summative assessment is more static and oriented to measure progress of learning after process. Additionally Summative assessment is more valuable for research purposes then formative because of its quantifiability.

MOOC in it's core meaning is the technological learning environment that teaches student how to become self regulated learner (Pintrich, P. R. & Zusho, A, 2002). This types of learning show different abilities of student, more specifically how can he approach, control and modify the different ingredients of learning activity. Ability to control their thinking, manage their motivation and modify methods of learning when appropriate. Generally MOOCs are focusing on the area of lifelong learning and idea of formative assessment is closely interconnected with this area.

For the final accreditation of student there is necessary to use summative assessment. Summative assessment is important in the way of standardizing and arranging outcomes of students progress through different academic institutions and topics which are based on similar type of teaching approaches. Considering different types of nature of MOOC assessment methods vary. Author will concentrate attention on assessment method based on xMOOC, because they are more standardized and well tested and implemented in academic practice.

3.1.2 Issues related to accreditation

From the issues regarding to accreditation is important to underline issues related with gaining academic credentials after completing MOOC studies. Authentication and proctoring of student is very important, because the proposed MOOC offers master level course in blockchain tech, with appropriate ECTS credits. Academic institution should be fully confident during the granting the credits that the person who was taking the course and final assessment is exactly the same. Identity and authentication of person is important issue and there are various technological tools and methods are exploit to verify identity. Nowadays MOOC platform providers use almost similar methods for identification of student. Cousera uses government issued ID, passport or driving license, additional technological solution is a keystroke recognition. EdX verifies person using photo and ID or additional state document. Udasity is using live interview after the completion of the course with combination of ID or some other official documents.

Proctoring as verification method is usually used for summative assessment, because of the high

cost of the process. Typically it is conducted in two ways. First method is using physical testing place such as libraries, private testing environments or university facilities, requires students physical presence. It becomes difficult when participant are from different countries. Second method uses technological process for proctoring webcam proctoring. During the exam academic staff is monitoring student and his activities by web camera taking this eyes movement and keystroke patters. There are some organizations that are offering this service on professional level but as mentioned above it is related to high cost starting from 100 dollars per student. In order to provide great confidence in assessment of student it is important to have authentication and proctoring processes on high level.

4. Defining constituent courses of study curricula

For defining MOOC curricula it necessary to consider wider nature of blockchain and cryptocurrency technology. This technology is situated on crossroad of finance, computer science, mathematics, law, sociology and politics. Taking in account this, focus of curriculum will be oriented on two major directions. First is a finance, including elements from micro and macro economic principles and the ways the technology can compliment or replace components of existing global financial system. Second is computer science including topics form cryptography, system security, systems scalability, and distributed computing. In next paragraph author will outline main constituent courses of the curricula and their objectives which are generated from the general objectives of blockchain tech course. Courses are generated to flesh out main knowledge areas and topics, which are necessary to cover to facilitate effective transfer of knowledge for gaining holistic understanding of blockchain technology and its potential.

4.1 Objectives of constituent courses courses

1. Introduction to Cryptocurrencies

The course will present an initial exploration of digital currency bitcoin. Overview theory and basic principles, how bitcoin operates and practical examination of basic transactions (Andreas M. Antonopoulos, 2015). It will also present cryptocurrencies from the perspective of banking,

financial institutions and emphasize regulatory frameworks and legal aspects associated with cryptocurrencies.

2. Money and Banking

The central goal of the course is to deliver understanding of money and banking, examine them from the critical viewpoint as the main pillars of societies functionality and overview possibilities of applying digital currencies to them (New your times, 2014).

3. Introduction to Blockchain technology

Course will provide knowledge of blockchain technology it's associated with predecessors through the history of computer science. Examine implications of blockchain technology from wider perspective for financial and industrial immutable record keeping (Viany Gupta, 2015). Examine core constituent parts of the technology and operational process under the hood. Course also discuss permission less and permissioned nature of blockchain technology and suitability of its application in different industries (Melanie Swan, 2015). Explore concept of sidechains and their role in interconnectivity and interoperability of different actors.

4. Blockchain technology and existing financial Systems

The objective of the course is to examine and equip student with understanding of existing global financial system and it's key pillars, overview it's structure and functional process (Richard Gendal Brown, 2013). How blockchain and distributed ledger based technology (The economist, 2015) can replace or enhance existing parts of this financial systems and what will be the main obstacles and opportunities in doing so.

5. Smart contracts, DAO and automatization of business collaboration.

Course will provide the understanding of Smart contacts (Jay Cassano, 2014) overview history and origins of this technology and it's possibilities to automate almost any kind of business collaboration

(Alex Norta, 2015). Course also present and analyze existing smart contracting platforms and their applicability in different industries. Student will gain insights on decentralized autonomous organization as a conceptual direction facilitated by blockchain technology and associate this concept of DAO with first working example such is Bitcoin itself.

6. Regulation issues regarding Blockchain technologies, smart contracts and crypto currencies

Course will introduce students to the emerging legal nature of blockchain, smart contracts, crypto currencies and DAO. It will examine main differences and similarities between regulatory frameworks of sovereign currencies and crypto currencies and inspect current regulation landscape and best practices of crypto currency regulation (Jerry Brito, Andrea Castillo, 2013). Implications of applying blockchain technologies and crypto currencies in the field of taxation, auditing, accounting (Fincen, 2013). Present ways how to harmonize and modify legislation in order to fully exploit the potential of this technology and possible challenges and opportunities

7. Disruptive Innovation and exponential technologies

The main aim of the course is to review the innovation form the point of view of the management, the economy and policy making. Course will examine history of disruptive innovations and how it affected field of management. All this issues will be explored considering paradigm of blockchain technology and crypto currencies and new business models based on them. Course explore wider concepts of emerging shared economy, it's P2P interaction patterns and transition ways form existing economical reality.

8. Hackathon project

One of the constituent courses will be the hackathon projects. The objective of hackathon is to encourage innovative and entrepreneur spirit of students and give ability use in practice gained theoretical knowledge from the accomplished courses. The aim of hackathon will be to come up with innovative solution in blockchain and cryptocurrency field. Students can design and prototype applications and artifacts and apply innovative power of cryptocurrencies and blockchain technology in any desired sphere. Course overview and teaches the basic principles of startup and

entrepreneurial culture, with guest lecturers from the startup field and explore best examples and case studies to prepare the students to creative process of final hackathon event.

9. Cryptographic and security principles of blockchain technology

The main goal of the course it to acquire knowledge of cryptographic protocols and functions used in blockchain technology and cryptocurrencies in general (Simon Barber, Xavier Boyen, Elaine Shi, Ersin Uzun, 2012). Apply the data protection, computer and network security frameworks to crypto currency paradigm. Examine best security practices and frameworks used in existing Crypto 2.0 environment. Course will equip students with effective skills to draft and manage appropriate security policy in their future projects.

10. Digital Currency Programming

Course will offer students theoretical and practical knowledge on blockchain and cryptocurrency software architecture and help them sophisticate this knowledge in practical examples and tasks (bitcoin wiki, 2010). Students will learn how to develop different smart contracting and e-commerce applications, cryptocurrency implementations, issues with creation and mining process of cryptocurrencies. Practical application skills of blockchain technology to e-commerce and different type of public and private projects.

11. Distributed Systems

Course will offer knowledge of core principles for design and implementation of distributed systems which are required to create and deploy blockchain and cryptocurrency (Satoshi Nakamoto, 2008) applications. It will examine distributed systems algorithms, frameworks, and models form the Crypto 2.0 perspective. Review peer to peer systems and their architectural principles for developing various frameworks for Blockchain and cryptocurrency projects.

12. Cryptocurrencies and Developing economies

The central aim of the course is to examine how financial and other institutional systems in developing countries may benefit form blockchain technology and cryptocurrencies (Alastair G. Clegg, 2014). What are the opportunities for them to leapfrog existing level of devilment and

implement state of art technologies for integrating themselves in global financial network and bring greater transparency and agility to their public institutions.

13. Blockchain technology, Cryptocurrencies and information systems

The objective of the course is to equip students with knowledge of theoretical frameworks and develop their proficiency in managerial issues regarding implementing, assessing and managing blockchain technology based on information systems. (Jan A. Bergstra, Karl de Leeuw, 2013) Course will present conceptual models of P2P architectures, Cryptocurrency based transaction and settlement systems, Privacy and anonymity issues related with cryptocurrencies, alt coin environment and overview main players in emerging crypto 2.0 ecosystem and their best practices.

14. Thesis project

Final accomplishment of the course will be the master thesis. Thesis encompasses all the theoretical and practical knowledge in the fried transferred by the entire course.

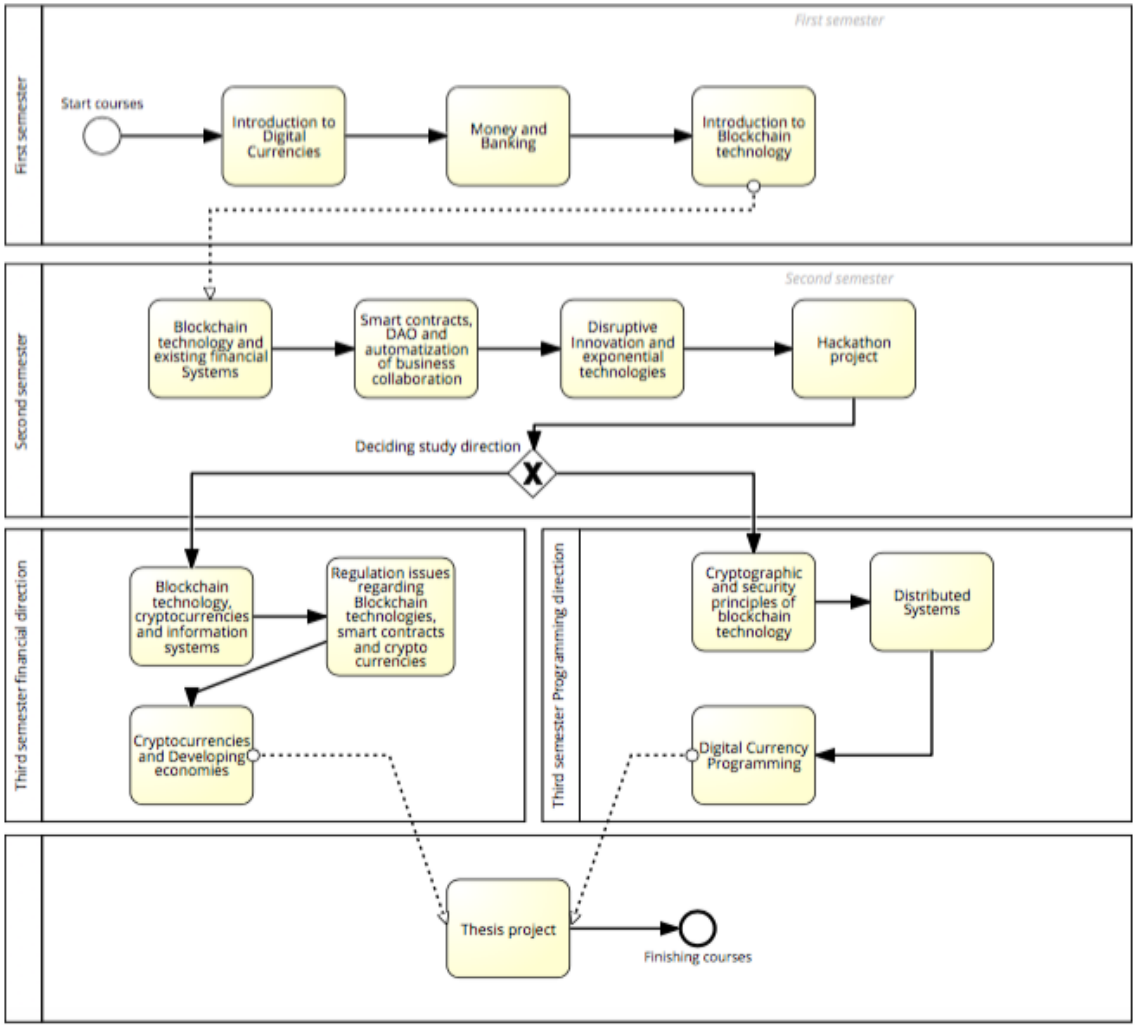

Figure 10. Entire curriculum map

Figure 10 presents entire curriculum map based on generated courses in this paragraph. Figure is divided into three semesters. First semester is consisting form the three courses Introduction to digital currencies, money and banking and introduction to blockchain technologies. Second semester consisting from four courses blockchain technology and existing financial systems, smart contracts, DAO and automatization of business collaboration, disruptive innovation and exponential technologies and finally hackathon project. Third semester is divided on two direction one is a financial direction for students interested in financial side of technology and second is programing direction for students with computer science background. Finally program will be accomplished with master thesis which will summarize all the theoretical and practical knowledge transferred by MOOC.

4.2 Content for the courses

This chapter will present content of each constituent courses of the MOOC for Msc-level blockchain tech. Each course will have 10 to 12 topics, per topic per week. Consequently approximate duration of each course is from 10 to 12 weeks. Chapter 4.3 will provide approaches and tools for pedagogical strategies based on active learning instructional strategies and assessment methods used by current MOOC providers and proposes active learning technics on the example of one course: introduction of cryptocurrencies.

1. Introduction to Cryptocurrencies

Course Contents:

1. History of money: From different early forms used as commodity exchange to cryptocurrency
2. The problem of the Byzantine' General. Understanding of one of the primary issue solved by bitcoin protocol. It's importance, history and development.

3. Core elements of cryptocurrency: meaning of Public and private keys, transactions inside the bitcoin protocol and understanding role of mining.

4. Practical overview of bitcoin protocol and main elements: Bitcoin core, online wallets, how to send and receive bitcoins, additional type of bitcoin storage cold storage and paper wallet.

5. Blockchain underling technology of bitcoin and wider understanding of it's potential. Colored coins, blockchain as an asset register, notarization function, smart contracts, Decentralized autonomous organization and political implications of technology.

6. Alternative cryptocurrencies: overview of alt coins space Litecoin, Dash, Dogecoin, I owe you based crypto currencies. Different types of protocols using modified blockchain technology and similar monetary principles of bitcoin: Ripple, stellar. Overview of Ethereum smart contracting platform.

7. Central Banking and cryptocurrency: Application of cryptocurrency principles to different core functions of central banking such as monetary policy, money supply and fractional reserve system.

8. Financial Institutions and cryptocurrency: Application of cryptocurrency principles to different fields of financial institutions such as: banks, money transition, exchanges and capital markets.

9. Regulatory frameworks and taxation of cryptocurrencies. Attempt of regulating cryptocurrency example of bit license. Consumer protection, KYC and AML frameworks.

10. Permission's innovation and blockchain technology. What are the core innovation elements and how it can reshape existing financial landscape.

11. Developing world and cryptocurrency technologies: Challenges and opportunities of public and private organizations in developing world in the process of adoption blockchain technologies and cryptocurrencies.

2. Money and Banking

Course Contents:

1. History and development of Money.

2. Different types of money and how classification of various cryptocurrencies associated with them.

3. Can cryptocurrencies employ same functionality of money.

4. Basic macroeconomic elements and their relation to cryptocurrencies.

5. Role of banking infrastructure as financial intermediary and peer to peer nature of cryptocurrencies.

6. Money issuing principles inside of the fractional reserve system and relevance of it with cryptocurrencies.

7. Demand and Supply of money in existing economical reality and reimagining of parallel principles in cryptocurrencies.

8. LIBOR and investment rates and reimagining of parallel principles in cryptocurrencies.

9. Time-Value of Money and reimagining of parallel principles in cryptocurrencies.

10. Cryptocurrency and Central Banking.

11. Monetary Policy in a code. comparison of existing monetary policy and algorithmic principles of cryptocurrencies monetary policy (Inflation, deflation and etc).

12. Practical work: Create a monetary system based on cryptocurrency.

3. Introduction to blockchain technologies.

Course Contents:

1. Blockchain technology and overview it's core functioning principles

2. Blockchain as new type of database analyze of sociotechnical implications of technology

3. Political implication of blockchain technology.

4. Blockchain technology in banking, insurance and in financial services industries, Debate over public and private blockchains.

5. Technical limitations and ways to move forward, debate about block size.

6. Blockchain technology, payment infrastructure and Fintech.

7. Overview of blockchain technology landscape: Multi party computation, communication and file storage.

8. Overview blockchain developing platforms and API

9. Sidechanes their theoretical principles signifies and future.

10. Blockchain technology and smart asset registration platforms. Challenges and opportunities for public and private sector. Example of Colored Coins, Counterparty, Nasdac blockchain platform , Openchain.

11. Case study of Bitnation opens source e-government platform and Estonian project e-residency: offering e-services world wide

4. Blockchain technology and existing financial Systems

Course Contents:

1. Examination of core constructs of financial and payment systems and parallel reimagining of their architecture in blockchain technology based systems.

2. Existing real-time gross settlement funds transfer systems (Fedwire, Target2, CHIPS,) and their corresponding in blockchain-technology based systems.

3. Clearing institutions and systems ACH, EFTS and their corresponding in blockchain-technology based systems.

4. Cryptocurrency based P2P systems and existing money transfer systems (Wester union, Money gram, etc).

5. Credit Card Networks and their corresponding in blockchain-technology based systems.

6. New Payment Systems in Fin tech and their corresponding in blockchain-technology based systems.

7. Securities: Traditional exchanges and analogues in blockchain based systems

8. Custodian institutions, securities and related operations with them such as settlement, clearing and their corresponding in blockchain-technology based systems.

9. New trends in economy: crowd-Funding, peer-lending and micro payments.

10. Data and Analytics and new way to exploit their potential by public blockchains.

11. New decentralized opportunities of asset registration using blockchain technologies.

12. Project and Class Exercise.

5. Smart contracts, DAO and automatization of business collaboration.

1. Smart contracts, history of origination and existing situation.

2. Problem of trust: institutional theory and role of intermediaries.

3. Blockchain technology as an enabler of smart contracts.

4. Examples and types of smart contracts and their design. Protocols for smart contracts. Their deployment and enforcement.

5. Analysis of smart contracting platforms emerged from Cryptocurrency ecosystem (etherium, counterparty, codius, bithalo etc).

6. Smart contract and business process management and automatization. Application and use cases for smart contracts.

7. Multi signature transaction, escrow transactions and oracles

8. Smart contracts, blockchain technology and IOT example of IBM adept.

9. DAO theoretical principles and future implications

10. Legal end regulatory framework for smart contracting, barriers for implementation

11. Identity and reputation management in smart contracts.

12. Case study of Ukrainian government implementation of e-auction with smart contracts and blockchain technology

6. Regulation issues regarding Blockchain technologies, smart contracts and crypto currencies

Course Contents:

1. Main principles of regulatory frameworks in Money and Banking

2. Existing regulatory approaches for cryptocurrencies and blockchain technologies overview buy countries.

3. Different theoretical issues regarding of regulation of banking and financial services

4. Self regulation and statutory regulation comparison

5. Different regulation frameworks such as know your costumer, anti money laundering and bank secrecy and their enforcement methods on cryptocurrencies

6. Taxation of cryptocurrencies.

7. Different options of accounting and auditing regulatory issues and their applicability to cryptocurrencies.

8. Consumer protection and corresponding issues in cryptocurrency regulation.

9. Securities, Pension and Retirement regulations as applied to Digital Currencies

10. Commodities regulation issues and it's applicability to cryptocurrencies.

11. Smart contract's and DAO 's regulation Issues.

7. Disruptive Innovation and exponential technologies

Course Contents:

1. Innovative products, services and business processes. Spreading of innovation and correlation of this process to the product life cycle. Cryptocurrencies as a new innovative product

2. Innovation management. How to develop new innovative strategy, business models, innovation in small and medium enterprises, financial resources for funding innovation.

3. where innovative ideas come from: discovering networks of innovation.

4. How to implement innovation in organization: Creating new products, services and processes. Employing open innovative resources and collaborations networks.

5. Change management and it's role in adopting innovation: exploit innovation by organization and utilizing the opportunities and knowledge gained.

6. The main characteristics of disruptive innovations: how to gain understanding about exploit them.

7. Tools and mechanisms of new technologies that are transforming business with exponential rate

network effects of innovative technology adoption and the technology acceptance model.

8. Cryptocurrencies and blockchain technologies as a disruptive innovation positive and negative side of this technologies and their competitive advantages.

9. disruptive innovations case study will include overview of Napster, Skype, Torrents, Bitcoin and 3D printing.

10. Case studies on Blockchain and cryptocurrency innovation: Cases include Bitcoin, Ethereum.

8. Cryptographic and security principles of blockchain technology

1. Security in the digital world and basic elements of security frameworks introduced in bitcoin. Comparison and assessment of this elements on example of different mainstream cryptocurrencies Litecon, Dash, Monero, Peercoin and etc.
2. Symmetric Ciphers – history of it's development, traditional encryption methods, symmetric encryption and it's characteristic. Examples of using symmetric encryption techniques in cryptocurrencies
3. Asymmetric Ciphers – history of it's development, cryptographic algorithms of public key cryptography and associated protocols. Examples of using public key cryptography in crypto currencies
4. Definition of hash functions and application in cryptocurrency. Cryptographic hash Functions, Mac algorithms for preserving and authorizing message integrity, digital signatures and their role in cryptocurrency.
5. Management principles of cryptographic keys and realization of this principles in different mainstream cryptocurrency protocols.
6. Different methods (password, token) of user verification. Overview of authentication and certification network protocols such as PKI (public key infrastructure) and Kerberos and etc. Issues related with anonymity in cryptocurrency protocols.
7. smart contracts and exploration of their cryptographic and security principles. Overview of main smart contracting protocols and their security frameworks.
8. Exploration of security principles on the level of IP and Web (web sites, application and services) security evaluation of this principles in cryptocurrency protocols.
9. Definition and examination of different kinds of computer attacks. Various risk factors in cryptocurrency systems and examples of computer attacks in recent history of cryptocurrencies.
10. Different techniques of network protection and security.
11. State of art in security measures applied in cryptocurrency and smart contracting protocols and underlying processes.
12. Security principles and required standards in cryptocurrency and smart contracting protocols from the regulatory perspective.

9. Digital Currency Programming

1. Transactions in Bitcoin network and their fundamental characteristics from programming perspective.
2. Examining transaction scripting language in Bitcoin. mechanics and limitations of scripting language.
3. Cryptocurrency clients and APIs for integration of different functionalities.
4. How to create new cryptocurrency. Altcoins and their characteristics. Colorid coins and smart asset integration possibilities.
5. Mining of cryptocurrencies, core mechanics and underlying principles. Different type of mining hardware CPU, GPU and ASIC and their characteristics.
6. Smart contracts from programming perspective and it's fundamental elements. Examples of smart contracts development in Ethereum Frontier protocol.
7. Design, implementing and operating private blockchains.
8. Cryptocurrency security. Risks and countermeasures for risk mitigation.
9. Integration of cryptocurrency based payment systems in e-commerce.
10. Cryptocurrency and blockchain: building API and libraries

10. Distributed Systems

1. Distributed Systems: history and evolution. Resource sharing in distributed systems. Characterization of distributed models in cryptocurrencies.
2. Overview of three types of distributed systems models: physical, architectural and fundamental. Exploration of ways for applying this models to cryptocurrency
3. Interprocess Communication of distributed systems
4. Indirect communication frameworks implemented in different types of cryptocurrency.
5. Distributed objects and components and their models in cryptocurrency system architecture.
6. Overview of peer to peer systems architecture. Examination of torrents and Napster architecture and comparison of it with Bitcoin. Overlay network and cryptocurrency.
7. NameServices in distributed systems and their overview in cryptocurrencies.
8. Global states and time in distributed systems and their application to blockchain technology.
9. Coordination and agreement in distributed systems and their implementation models in

blockchain technology.

10. Distributed transactions and their types and supporting architecture

11. Case study on how to design and implement distributed systems architecture for blockchain technologies.

11. Digital Currencies in the Developing World

Course Contents:

1. Overview of demography statistic in the developing countries.

2. Economic grow and basic macroeconomics trend overview in develop countries.

3. Path for reaching from developing county status to developed country.

4. Core institutional functioning (financial and legal) overview in developing countries.

5. Overview of differences in marketing of consumer products and their distribution in developing and developed world.

6. Innovative payment systems on the example of Mpesa and their role in adoption of cryptocurrencies in developed world.

7. Challenges and opportunities of blockchain technologies and cryptocurrency in terms of rapidly deploying financial infrastructure and new e-government platforms in the Developing World

8. Peer to peer lending micro financing and opportunities of blockchain based decentralized systems.

9. Case Studies: Mpesa, cryptocurrency based money remittance operators.

12. Blockchain technology, Cryptocurrencies and information systems

Course Contents:

1. overview of electronic payment systems and cryptocurrencies.

2. Core theoretical and practical knowledge of P2P systems and their decentralized architectural

principles.

3. Fundamental issues of Security in Cryptocurrency ecosystem.

4. Overview of digital Wallets and analysis of their main competitive advantages.

5. Specifications of requirements for expanding the Cryptocurrency ecosystem.

6. Cryptocurrency exchanges and challenges associated with them

7. Mobile computing and new services in cryptocurrency.

8. Mobile services in a cloud.

9. Alternative models of cryptocurrencies.

10. Investment possibilities of cryptocurrency and their Derivatives.

11. Privacy and Cryptocurrency.

12. Case Studies of state of art in cryptocurrencies.

4.3 Developing pedagogical strategies

This paragraph will present pedagogical strategies that are appropriate to use in MOOC. Paragraph starts with the Cone of experience framework for determining, which pedagogical strategies are most effective for transferring knowledge.

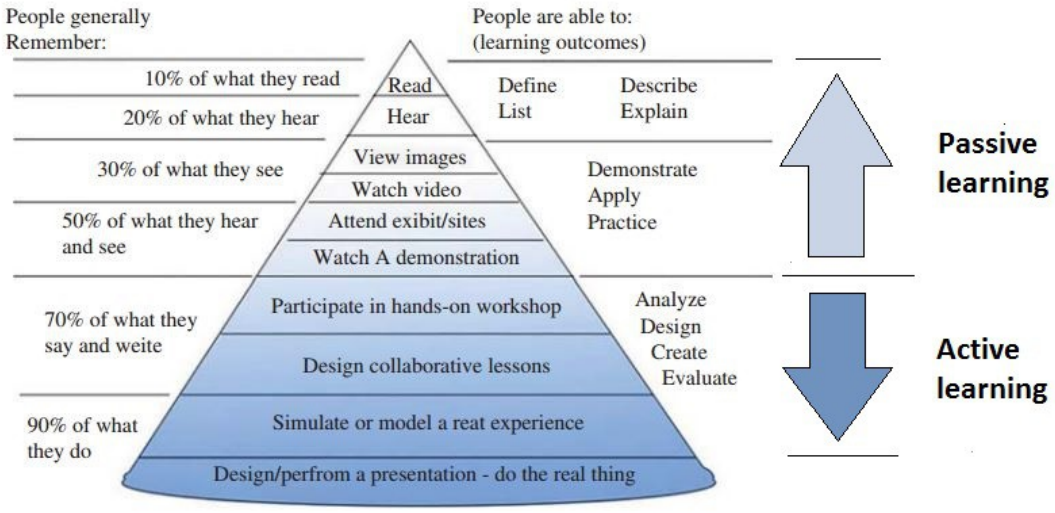

Figure 11. Cone of experience of information retention by Edgar Dale

Cone of experience was developed by Edgar Dale in 1946, cone maps and presents ranking of efficiency of how people retain information received from different sources (Dale, Edgar.; 1969).
Based on Figure 11. bottom of the cone is consist from concrete, real-life experiences, that are created from direct interaction with people, from participation in specific events playing specific role, with determined goals. So, generally base of the cone is reflects how effective is information retention, when learners learning things from actually doing it, participating in process of doing (Beverly Davis, Michele Summers, 2014).
The middle part of the cone reflects situation, when the learner is more in the role of observer. So they are participating in process not by acting (playing some particular role), but rather passively by observing. Abstraction level in the middle part of the cone is bit high then in the base part. As we see from the figure 11, middle part of the cone is more characterized with the verbs of listening, watching, attending.

The top of the cone is most abstract, where the experience is developed from passive learning by observing the phenomena from visual or auditory perception.

In summary cone developed by Edgar Dale is very useful visualization for understanding how different types of pedagogical methods affect the process of learning or internalization of information by learners. In the top area of the cone level of information retention is very low and ineffective this area is generally corresponds to passive learning, when information is obtained from the role of observer. As you move down of the cone information retention rates are increasing, because learner role is changing from observer to participant. Base area of the cone is corresponds with active learning (learning things by doing). Stated above facts leads us to the understanding that using active learning approaches and pedagogical techniques is most effective way of transferring knowledge to students.

4.3.1 Active learning

Active learning is a method of learning, where learners are actively engaged in learning activity meaning, that their learning comes from acting, rather than passively observing phenomena. Phrase was first coined by R W Revans (Revans, 1983). This method promotes self directed learning by imposing responsibility of learning on learner, instead of traditional style learning, (teachers speak and students listen) when teacher or lecturer is responsible for your learning.

Method of active learning became popular in 1990s with the monograph named “Active learning creating excitement in the classroom”, (Bonwell & Eison 1991). Monograph presents different approaches for build up active learning practices in classrooms and interconnects three domains of learning namely: knowledge skills and attitudes of learner with active learning method as a tool for achieving particular concrete goals for this learning domains. Depending on monograph active learning practices engage student in performing things and thinking about the things what they are performing. Active learning methods encourages and cultivates in student higher level thinking competences of analyzing, designing and evaluation. This competences are the most effective ways for information retention and effective realization of learning (see the Figure 8)

Guiding principles of Active learning are closely connected with constructivism learning theory where knowledge construction based on how a person interacts with the environment and experience the world.

Active learning practices

There are various techniques to integrate active learning in curriculum, below author will describe few of them.
Problem based learning, when group is engaged in developing solution for particular problem. Collaborative learning -doing tasks in groups. Role playing, with some specifically designed scenarios, debating - when students are divided on different parties and debate specific issues from different perspectives. Case studies, simulations, laboratory activities and *etc.*

Examples of active learning pedagogical techniques:

A **group discussion** activity can be conducted in face to face or online environment. This activity is more effective with a group consisting of small amount of student. Instructor plays role of moderator. This technique is effective after teacher has presented particular topic and then intrudes group discussion as follow up activity to deepen understanding on already presented topic and analyze it from different perspectives (McKeachie, W.J., Svinicki, M, 2006). This technics cultivate skills synthesis in student (Brookfield, S. D, 2005)

A **learning cell** technics is randomly pairing students together and asking them to come up with questions for other group, from already known or previously discussed material (B. Goldschmid, 1971). Then it followed by asking of the questions and discussion around this questions between two groups, involving also participation of different groups.

Collaborative learning involves learning with groups. Main approach is to divide students in groups of 5 people and to work collaboratively on solving some task or doing project based assignment. For effective formation of group in online environment it's necessary to clearly clarify roles and objectives of the group and its members and have close interaction during the

collaboration process. Instructor should have the proactive role. (McKinney, Kathleen, 2010).

S**tudent debate** is another good practice of active learning. Instructor gives particular topics for debating and student should analyze information around this topic and defend their position, also examine arguments of opponent form critical perspective. This technics strengthens students analytical, logical reasoning and presentation skills (McKinney, Kathleen, 2010).

One of effective practices of active learning is a **reaction to a video**. Effectiveness on this method based on the fact that you can transfer big amount of information in a small video lecture and trigger discussion based on facts and concepts presented in a video. Also it is a perspective from different angle (alternative way of presenting information) on already discussed issues and topics. It is desirable practice to articulate on specific ideas in the video before watching it to draw attention of students for deeper learning of the issue. After the watching of video instructor can initiate discussion inside the group or ask students to write short critical review.

A small **group discussion** are good method for increase participation of students in discussion process. In comparison with large group or classroom, the small groups are more comfortable way for some students to speak out and express their ideas (Harmann, Kerstin. eric.ed.gov. 2015.). There are different approaches for group discussion: create competitive scenario for group or to design game type assignment.

Learning By Teaching, active learning practice is very effective instructional method due to fact that students feel the responsibility to prepare topic for teaching to their peers and this factor of responsibility is additional motivation to research and master the topic and transfer this knowledge in an easy and understandable way. Additional point for learning by teaching method is that communication between peers of students is more casual and it helps to better knowledge transfer.

Problem-based learning or PBL is the approach to learning (part of active learning), when learning is realized thought process of solving particular problem, to put it shorty students are gaining knowledge about domain by solving particular problem of this domain. PLB technique was developed initially in medical education in Canada and then adopted by different disciples around world, due to its effectiveness.

This method is part of student centered learning and promotes self directed learning, autonomy of student and what is most important it develops practical problem solving skills (Antepohl, W; Herzig, S. 1999).

The instructor's role is to support and direct process of learning and scaffolding activities are more appropriate in the beginning of the learning process.

Problem based learning is very tightly linked to the notion of lifelong learning, because it develops autonomous learners, who can easily determine their goals, research appropriate sources and methods of learning for archiving their objectives and then follow developed road map. Autonomous and self-directed learners have clear realization that responsibility for learning and have high level of self-motivation, which is one of important factor in effective learning process. (Candy, P. C. 1991).

Additionally, important benefit of problem based learning is the fact that problems are taken from real life cases, so in the future during the career path student will already have knowledge, skills and competence that can be adapted to apply to the similar problem scenarios at work.

4.4 Integrating active learning strategies in course: introduction to cryptocurrencies

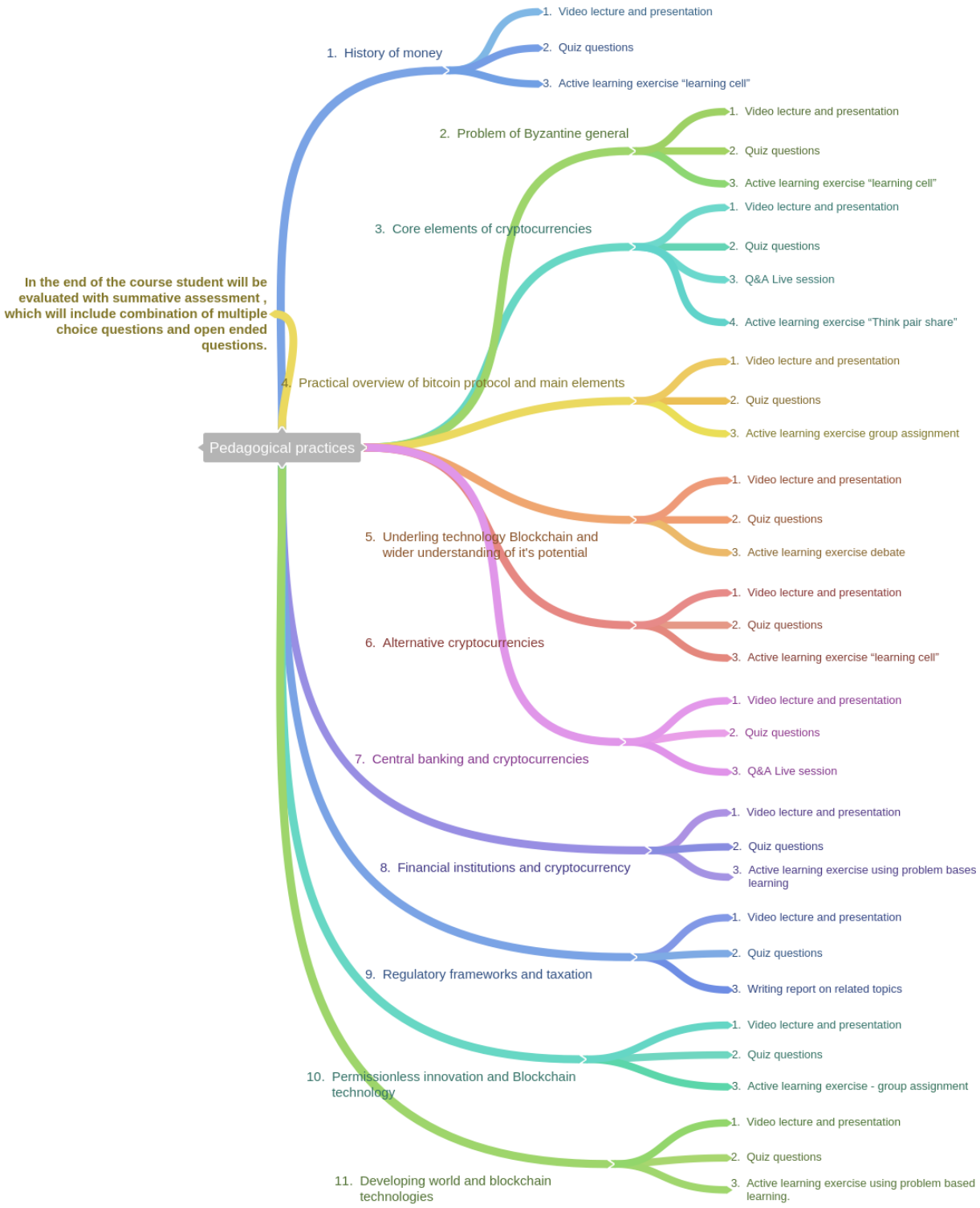

Figure 12. Map of active learning practices integrate in the course: introduction to cryptocurrencies

1. Introduction to Cryptocurrencies

The course will present an initial exploration of digital currency bitcoin. Overview theory and basic principles, how bitcoin operates and practical examination of basic transactions (Andreas M. Antonopoulos, 2015). It will also present basic mechanics of blockchain technology and cryptocurrencies from the perspective of banking, financial institutions and emphasize regulatory frameworks and legal aspects associated with them.

Example of integration active learning practices in the course: Introduction to Cryptocurrencies

1. History of money: evolution from different early forms used as commodity exchange to cryptocurrency

Activities for the topic: watching the video lecture and check presentation file, answer the quiz questions, participation in active learning exercise “learning cell”. For learning cell exercise instructor randomly selects pair of students and asks them to come up with a questions for different group, from discussed topic - history of money. Groups are posting generated questions on forum and answering on questions from another group.

2. The problem of the Byzantine’ General. Understanding of one of the primary issue in computer science solved by bitcoin protocol. It's importance, history and development.

Activities for the topic: Watching the video lecture and check presentation file, answer the quiz questions, participate in active learning exercise “learning cell”.

3. Core elements of cryptocurrency: meaning of Public and private keys, transactions inside the bitcoin protocol and understanding role of mining.

Activities for the topic: watching the video lecture and check presentation file, answer the quiz questions, participate and post questions for Q&A Live session with P2P decentralized mining pool, participate in active learning exercise “think pair share”. For think pair share exercise instructor randomly groups students and gives them reading materials, and ask them to discuss and share answers on the questions from assigned material. After discussions between each other, students should post answers on forum.

4. Practical overview of bitcoin protocol and main elements: Bitcoin core, online wallets, how to send and receive bitcoins, additional type of bitcoin storage cold storage and paper wallet.

Activities for the topic: watching the video lecture and check presentation file, answer the quiz questions, participate in active learning exercise group assignment: group should research and present ideal characteristics for cryptocurrency

5. Blockchain underlying technology of bitcoin and wider understanding of it's potential. Colored coins, blockchain as an asset register, notarization function, smart contracts, Decentralized autonomous organization and political implications of technology.

Activities for the topic: watching the video lecture and check presentation file, answer the quiz questions, participate in active learning exercise - debate. Topic of the debate is to examine Blockchain technology form the critical perspective. Instructor randomly divided groups into opponent's (representative role from existing financial system) and proponents of the technology (representative role from Blockchain environment) debates are recorded via google hangout and then assessed by peer students based on the rubric introduced beforehand by instructor.

6. Alternative cryptocurrencies: overview of Altcoins space Litecoin, Dash, Dogecoin, I owe you based crypto currencies. Different types of protocols using modified blockchain technology and similar monetary principles of bitcoin: Ripple, stellar. Overview of Ethereum smart contracts platform.

Activities for the topic: watching the video lecture and check presentation file, answer the quiz questions, participation in active learning exercise "learning cell". For learning cell exercise instructor randomly selects pair of students and asks them to come up with a questions for different group, from discussed topic - monetary side of Altcoins and what are the characteristic of stable monetary policy for cryptocurrency.

7. Central Banking and cryptocurrency: Application of cryptocurrency principles to different core functions of central banking such as monetary policy, money supply and fractional reserve system.

Activities for the topic: watching the video lecture and check presentation file, answer the quiz questions, participate and post questions for Q&A Live session with Representative of European central bank.

8. Financial Institutions and cryptocurrency: Application of cryptocurrency principles to different fields of financial institutions such as: banks, money transition, exchanges and capital markets.

Activities for the topic: watching the video lecture and check presentation file, answer the quiz questions, participation in active learning exercise using problem based learning approach. Instructor randomly divides student into groups of 5 person and gives them task to come up with solutions to problems from different field of finance. They should research and present blockchain technology based solution for given problem.

9. Regulatory frameworks and taxation of cryptocurrencies. Attempt of regulating cryptocurrency example of bit license. Consumer protection, KYC and AML frameworks.

Activities for the topic: watching the video lecture and check presentation file, answer the quiz questions, participation in active learning exercise. Instructor assigns to write report about legislation practices by countries and how these practices should be harmonized to harvest full potential of cryptocurrency technology, regarding cryptocurrencies.

10. Permissionless innovation and blockchain technology. What are the core innovation elements and how it can reshape existing financial landscape.

Activities for the topic: watching the video lecture and check presentation file, answer the quiz questions, participation in active learning exercise group assignment. Instructor divides students into group of 2 student. They should pick one particular aspect of the innovative potential of technology research it and write assignment on this topic of feasibility of application of their possible solution in existing financial landscape. Then student should

11. Developing world and cryptocurrency technologies: Challenges and opportunities of public and private organizations in developing world in the process of adoption blockchain technologies and cryptocurrencies.

Activities for the topic: watching the video lecture and check presentation file, answer the quiz questions, participation in active learning exercise using problem based learning. Instructor divides students and give them problem to solve from private or public sphere in developing world. Groups should give present their solution and assessed by peer students based on particular assessment rubric.

In the end of the course student will be evaluated with summative assessment , which will include combination of multiple choice questions and open ended questions.

4.5 Digital tools used in MOOC to support Active learning pedagogy

In order to make learning experience more interactive, using of active and collaborative learning approaches is essential. Below author will overview some of the most important pedagogical strategies and tools used in current well established MOOC platforms. These strategies and tools are represent list of desired technics which will serve as a guideline framework for lectures in realizing learning outcomes presented in paragraph 3.1. Each particular strategy or tool will be adjusted on particular constituent course of curricula accordingly based on specifics of lecturer teaching experience, teaching topic and learning outcomes.

Lecture. During the many years the lecture method was the most widely exploited pedagogical strategy in traditional and online education. In spite of the other teaching approaches becoming powerful tool in learning process, the lecture is still one of the primary way to transfer and to communicate information in existing MOOCs.

In combination with active learning or teaching approaches, the lecture is an effective tool to achieve desired pedagogical outcomes. The positive side of the lecture approach is that it has ability to transfer large quantity of information to a wide number of students, it also helps manage pedagogical control over the audience in cases, when behaviorist teaching models are more appropriate for acquiring knowledge. The downside of lecture in online environment is a decrease feedback opportunities from learner, because sometimes it considers an unfeasible level of student comprehension and cognition, which often leads to disengagement of learner from the process of learning that in turn leads to forgetting information received during the lecture. This disadvantage usually is compensated with additional online real time communication tools such as online chats or forums or different video conference tools.

Case study Method. This method gives an opportunity for students to enrich theoretical knowledge gained during the studies, with experience of real-life scenarios and apply this theoretical knowledge to find solutions for real cases from different fields. During the using case study method approach students learn effective ways to disseminate and integrate existing body of knowledge for finding appropriate solution. This method is part of instructional strategy and good tool for engagement of learner for active discussion about problems in existing application. Use of case study method can underline core problems or critical points and provide a ground for role playing of different arguable and unclear scenarios. Content for case studies in proposed MOOC can be taken from different problematic issues in cryptocurrency environment which will be based on financial issues, security issues, Legal issues and etc. Based on this case studies students will acquire critical thinking experience and will gain multiple perspective on important topics in Cryptocurrency environment.

Cooperative Learning. Cooperative learning is a pedagogical approach that motivates students to cooperate with each other and achieve common outcomes. Cooperative learning approach is often associated with collaborative learning but in practice they are two separated things, collaboration learning includes wide range of interactions of communities. Nevertheless both of them underline the necessity of students participation and engagement in learning process. It is very important to plan carefully the integration in a course collaborative and cooperative learning approaches. For doing so it is necessary to think from the beginning how to form the group, guaranty and secure positive interconnection between group members and design sufficient assignment criteria to realize good results with cooperative learning experience. The Learning methods are vary but teamwork activities and discussion forums are very useful tool to unitize during teaching process.

Online discussion. There are variety of ways to stimulate online discussion. For example, some lecturer often start lecture with a group discussion about topics that was debated during previous lecture or topics that were given for research for home assignment, this pedagogical approach refreshes students memories and involves them in learning process. Noticeably positive and engaging online discussion considers carefully planning discussion topics from the side of lecturer and preparation and redness from the student.

Forums are very useful tools to facilitate online discussion on various topics the are important

source of collaborative knowledge accumulation. There are few types of forum to consider which can effect on the flow of conversation between student. Each type has a various posting specifications for example, some are useful to directly allow students to answer question posted by lecturer and some are used to give ability to students freely express their opinion and create stream of conversation about particular topic involving post from different students.
Standard forum is more widespread type of forum and well known for students and lecturers. Typically this format can be seen on many web pages that have space for forum discussion. Students can actively participate in discussion, post their own topics and respond to questions posted by lecturer and all posts are freely visible for all participants of the forum.

Single simple discussions is a format when lecturer posting his question or some topic for students to respond or to reflect on this topic. All posts are visible for participant.

Q&A Forum is almost identical to simple discussion type but with one main difference. After the lecturer is posting his question on forum, students answers are not visible to each other, in order to prevent plagiarism from students and maintain healthy generation process of ideas and responds. After some time when all students have finished the responding posted question, posts becoming visible and everyone can check or grade each others respond.

One good practice to utilize is a peer to peer rating functionality of each others questions or answers. For example if there is large number of participant in the form and they should post preliminary questions for some future discussion, with utilizing of this practice lecturer can sort quality of questions and answer on them appropriately, which is time consuming and effective way to support positive flow on discussion.

Online chats functionality is one of the useful tools to create enhance active learning process. It has main advantage over the forum because it facilities and supports conversation in real time and its useful way to quickly get in touch with group member and share ideas and opinions about particular topic in real time.

Social media technologies offer called Web 2.0 are also one of the important tool for active learning which facilitate student engagement. Web 2.0 encompass different types of web technologies such as social media, blogs, wikis, and other spaces that students find interesting for having engaging discussions. In cMOOCs social media is used widely to create free flow of knowledge generated network. But downside form pedagogical perspective of purely move

discussions in web 2.0 tools is linked in it's inability to track and measuring knowledge that each individual has received. Considering the chaotic nature of interactions inside knowledge network is also very hard to design sound assessment criteria and therefore this tool is not widely used in C types of MOOCs. Nevertheless in some courses proposed by thesis initiative of using different types of web 2.0 tools for different purpose will be welcomed.

Video lectures are core element in delivering content in MOOC. It is a primary pedagogical tool in well established mainstream MOOC platforms such as edX, Corsera, Udasity, Khan Akademy and etc. It is also important to mention that often cost of production of video lecture and materials are highest in overall MOOC design cost. Based on report analyzing engagement of students (Guo, P., Kim J., & R. Rubin, 2014) video lectures can be divided by two major categories: lecture videos and demonstration or tutorial videos. First is used for content delivery and is presented by lecturer, It may be accompanied by additional presentation slides. Second is used for demonstrating some practical solution by reviewing each step in the process. Second type is more appropriate for computer science disciplines. For the proposed MOOC in master thesis it will be appropriate to use video lectures as a primary source for course content delivery, it will be also useful to use youtube platform for online Q&A video lectures and Google Hangout platform in case of guest lecturer and panel discussions. Average time in above mentioned report for video lectures is recommended not to exceed 15 minutes. Common practices in majority of MOOC platforms are use of video lecture with combination of multi choice quizzes, this practices is linked to retrieval learning methodology and is very useful for enchasing long term memorability of particular subject.

Podcasts are very useful tools to knowledge transferring and getting knowledge from discussion on particular topic. Considering the fact that there are few interesting podcast channels regarding cryptocurrencies and blockchain (Lets talk bitcoin, Epicenter of bitcoin and etc.) technologies it will be appropriate to integrate different episodes from this podcasts into the course content.

multiple choice quizzes

The typical approach, which all established MOOC providers are using during the teaching MOOCs are lectures based on showing short videos about topic and videos are intercepted or followed by multiple choice quizzes (Orn, 2012).

This approach is justified by the argument that quizzes are good tools for retrieval learning. Retrieval learning is defined by the idea that long term remembering of information is strengthened by addressing facts from short term memory (P.K. Agarwal, 2012).

There are different variations of multiple choice questions, choosing from alternatives, from true or false and so on. In majority of MOOCs automated quizzes are combined with video lectures or presentations.

Peer assessment

Peer assessments are one of the new technics which address the problem of assessing massive number of student, where there is practically impossible to evaluate all the work by one lecturer or instructor. The main functionality is that assessment is conducted by peers or group of peers. Criteria of assessment is declared in advance, it can be analytical or critical as well as some other types. Pear determine competency of individual in specific tasks or additionally they present the judgment of activity of individuals in some time frame and weather he or she deserves particular points or status depending on the evaluation criteria. This method is different form traditional type of assessment, when professor or lecturer has clearly defined standards and competences. When using this technic competencies are socially negotiable and significantly vary inside different communities. Research data from exams that were assessed by peers in a course by Coursera named "Introduction to sociology "show high level of correlation between marks of the lecturer and marks of average five peer assess results (Lewin, 2012)

Roots for informal and formal peer assessments emerge from online communities or software development groups. For example Github and Stack Overflow software development platforms. Users of this platforms have developed over the period of time different interaction patterns and review methods to address task of finding solutions on technical questions. The platform develops methods of representation of value of particular projects by analyzing reviews and ratings originated

from the peers. Peer assessment method is a way of utilizing theory of wisdom of the crowd (James Surowiecki, 2004)

5. Choosing the right platform for hosting the MOOC

The huge popularity of MOOCs (Ellen Wexler, 2015) in online education have fostered creation of vast amount of MOOC providers, which are competing with each other, offering hosting platforms (John Swope, 2014), for MOOCs with different capabilities and tools for teaching and learning. This paragraph will try to research and define the right platform for the hosting of the MOOC proposed in master thesis. Initial criteria will be the long term experience in online education environment, open source code, number of user base and used technological tools on platforms from the teaching and learning perspective. There are two well recognized MOOC providers in existing online educational environment, which are best suited for mentioned above criteria, Moodle (Moodle LMS) and edX (edX).

edX

Edx is well established platform created by cooperation of Harvard and MIT. The desired goal to achieve for edX is to be Worldpress for MOOC. EdX has ability to accommodate 100000 student in a single course, which in comparison with moodle is very high number. Software in open source and code was published in 2013. Platform is very promising considering high rank of academical institutions taking part in it's development and 60 million venture capital behind it. EdX platform offers vast number of courses, but majority of MOOCs deployed are STEM courses. Although edX is an open source additional expenditure necessary for deployment and management of the platform.

Moodle

Moodle learning management system has thirteen years history of active participation in online education environment. Moodle is abbreviation for modular object-oriented dynamic learning environment. Moodle platform is open source, fully customizable and written in PHP. Moodle platform initially was designed as fully configurable LMS to serve as traditional online classroom. It much more easier to deploy MOOC on Moodle platform than on edX. In terms of educational

tools and analytics it is more advanced than edX, also Moodle platform is designed with full compatibility to SCORM standards. Also it is important to mention large community around Moodle which is good for developing perspective. However negative side of the platform is that it can not support large number of students as edX, maximum number of class is 10 000.

Registered sites	63,488
Countries	219
Courses	8,809,917
Users	79,386,523
Enrolments	220,323,489
Forum posts	158,162,061
Resources	80,281,088
Quiz questions	375,995,879

Figure 13. Statistical information of Moodle platform

According to figure 13 (Moodle LMS statistics, 2015) the number of Moodle platform users is approximately 79386523, number of courses and number of enrollments are also quiet remarkable. On other hand edX goal is to provide education to billion of users (Sheri Handel, 2015) in near future and this ambitious plan should be realized by engaging in cooperation with top educational institutions.

Below author will try to analyze this two platforms (based on documentation provided from their official web pages) for deployment suitability of proposed MOOC in Master thesis. Comparative analysis of the platforms are focusing on following categories: Course structure, tools for collaboration, reporting tools, tests and grades.

Course structure

During the comparison of Moodle and edX platforms there is clear difference in terms of how courses are organized and structured and presented for student.

Moodle platform (see figure 14) during the accessing to course shows full view of topics and resources needed for learning this topic. Organization structure is easy accessible and conveniently presented in the central part of the course page, while the left and right areas of the page are dedicated to additional tools such as calendar, chat and upcoming events, navigation throughout the different enrolled courses and other plug-ins.

In edX Platform (see figure 15) course structure is situated on the Left side of page and rest of the area is occupied by the course content and practices materials. For accessing to individual topic material student should open topic on the left side and explore it's content.

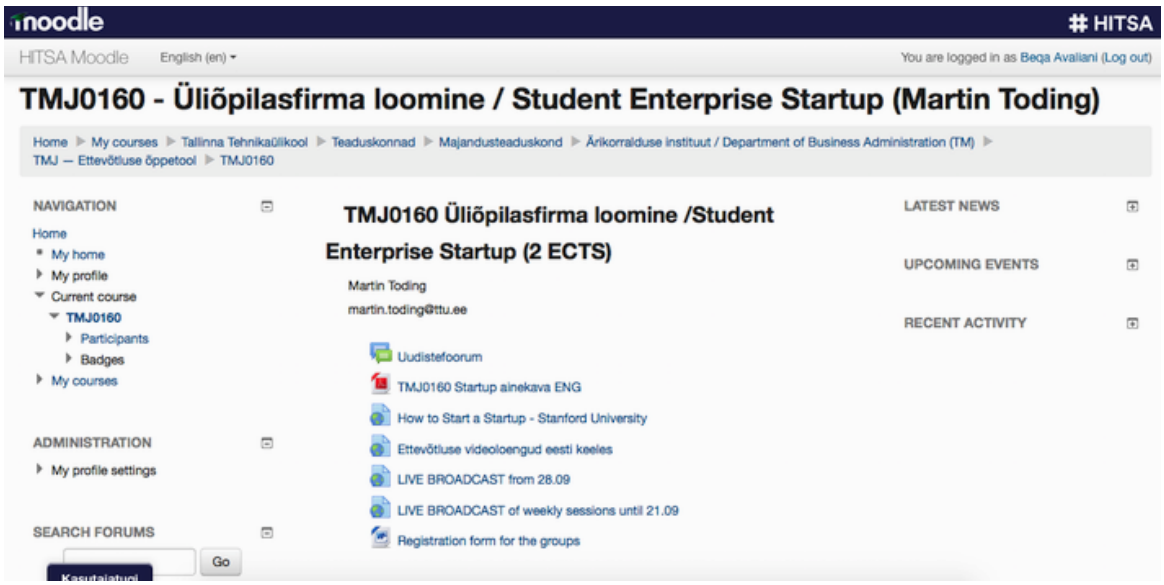

Figure 14. Screenshot of student study area in Moodle platform

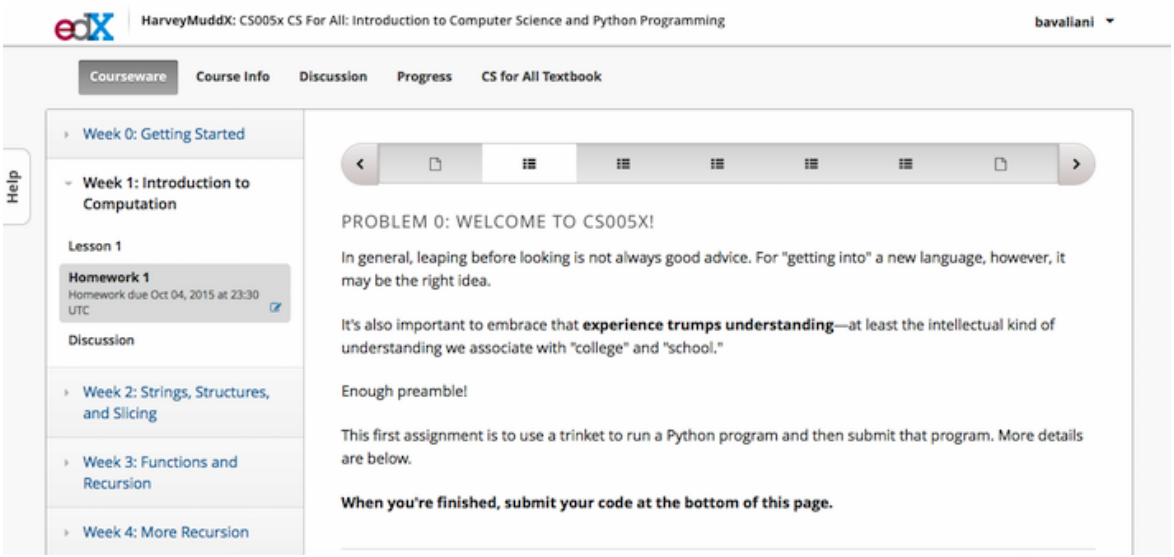

Figure 15. Screenshot of student study area in edX platform

Tools for collaboration

Both platforms have built in communication tools such as forum. But in comparison with edX, Moodle additionally supports online chat, which is more convenient and gives ability be rapidly engaged with peers and teachers. On both platform forums is well organized very intuitively fostering active collaboration and sharing of information. What more forum on Moodle platform has ability to support more types of discussion. As a conclusion in terms of collaboration tools Moodle platform offers more advanced options than edX.

Reporting tools

Reporting tools on user activity are supported by both platforms and both of them give possibility of exploration of various analytical data gathered from user or user groups depending on different characteristics of activity. But again list on Moodle documentation web page is much more wider than on edX. Moodle additionally has advance options supporting formats to export this data for further analysis and reporting. Visualization options are equally supported by both platforms.

Tests and grade options

Test options are provided by both systems, but they are different for some particular scenarios. Moodle has more wide choice of tasks, but edX platform is more easy to use and clearly defines all the pathways and responsibilities of students during the taking the task and also describes in details assessment and activities included in it. In terms of grading edX supports peer grading, self grading, grading from academic staff and machine grading, which is similar to Moodle platform. As a conclusion Moodle has better assessment options.

To summarize the results Moodle platform is supporting wide range of functionality with comparison to edX in terms of tools for collaboration, reporting tools and test and grade options. While course structuring and visual side of platform is more advanced in edX. Examination of this platforms clearly points on advantages of Moodle, so author derives to conclusion that for deploying the MOOC for MSc-level Blockchain tech courses Moodle platform will be appropriate. Additionally, academic institutions in Baltic region has long term experience in offering blending learning using this platform, which is supplementary argument for using Moodle as a host platform.

5.1 Evaluation of effectiveness of the MOOC

There are great number of research for evaluating effectiveness of e-learning, however not so many research papers are oriented on exploring effectiveness of learning process in MOOCs, due to it's recent phenomenon. There are different suggestion to use same techniques for evaluation effectiveness of the MOOC, which are used in e-learning (A.F. Yousef, 2014), but MOOCs have specific features due to their massiveness and openness that forces to develop different evaluation criteria for capturing effective learning.

Significant research in this direction is done by (D. Gamage, 2015). In her research she tries to explore MOOC's effectiveness framework from the perspective of learners. She uses Grounded theory (Glaser, B., & Strauss,1967) approach, because of lack of sufficient scientifically proven data and facts. In research paper she propose framework consisting from ten basic dimensions which are

constituent parts of effectiveness of learning in MOOC. In this framework last two dimensions collaboration and interactivity dimensions can be combined in one collaboration dimensions, because both of them are describing ability of participants of the MOOC to interact freely with each other learning and administrative issues. Framework also presents one distinctive dimension named as “Networks of opportunities”. This dimension reflects learners expectations from MOOC to provide opportunity for connection with networks of people where they can realize received knowledge and collaborate on specific projects with industry.

Presented dimensions author will map in conducted thought experiment for evaluation of effectiveness of presented MOOC. Dimensions will be assigned with ranking value: low if dimension is represented very weakly, medium if dimension represented but not on active level and high if dimension is strongly represented.

Dimension for evaluating effectiveness of MOOC (Gamage D, Fernando S, 2015):

1) Technology dimension:

This dimension explains the ability to continue learning in MOOC with the existing hardware, software. At the same time to be able to take lesions either synchronous or asynchronous modes of delivery.

2) Pedagogy dimension

This dimension explains the method of MOOCs learning delivery. How the learning notes provided, video chunks, the learning time and pace to have self pace or week by week continuation. At the same time the arrangement of the learning such as with aid of time to time direct discussions, hangouts, social media aid to enhance the delivery engagement.

3) Motivation dimension

This dimension explains the motivation to use the MOOC courses. Motivation was described by whether it keeps the attention of the participant by keeping the learning relevant. At the same time make the user confident in the provided learning while providing satisfaction of the overall course.

4) Usability dimension

Usability of the MOOC was identified by the interface design, navigation interactions, learning environment support to learners’ ability to learn and the facility provided to obtain feedback on any issue on the platform.

5) Content/Material dimension

This dimension will provide effectiveness by providing useful and relevant up-to-date content. Apart from that participants endorse to be effective in having rich multimedia and collaborative content.

6) Support for learner dimension

This dimension was required by many of MOOC participant as in MOOC scenario, learner is not directly involve in the institution or the platform. They were needed to provide psychological and social support. At the same time students required administrative support and a proper complaints procedure on the issues they face during learning in the platform.

7) Assessment dimension

Assessment dimension explained by students indicated they value collaborative assessment, mastery of the content or material, periodic assessment in program, satisfaction assessments and regular reviews of students' achievements.

8) Future directions/Network's dimension

This dimension revealed that MOOC students expect to have credentials or recognitions for their achievements in MOOCs to be effective. At the same time they embrace the exposure to other interest network of community whereby leads them into new opportunities, such as internships, projects.

9) Collaboration dimension

This was explained as effective if the students given chance to collaborate with other students, with institution, instructor and industry of their learning interest.

5.2 Thought experiment

It should be mentioned from the beginning that scientifically sound approach for assessment of the MOOC will be to assess it after one year of implementation based on gathered results from students and teachers interactions, combined with analytical information gained from platform. But bringing into account the fact that this is practically impossible due to non existence of this data, author will take different approach for evaluation of effectiveness of MOOC. Proposed assessment model and its dimensions will be applied to imaginary case created by through experiment with specific scenario.

Case will assume that course is taken by some student, which will take MOOC's particular course and possible scenarios. During this thought experiment valuable information will be generated, which will serve as a fundament for assessment. Received results will be mapped in assessment methodology and it will be the source of information for final MOOC evaluation.

Thought experiment will be based on imaginary scenario of student enrolling in MOOC Blockchain tech and studying first course - "introduction to cryptocurrencies and blockchain technology". During the thought experiment author will go throughout all process of studying and generate possible scenarios of student interaction with course platform, professor or instructor, peer students, lectures and materials, assessment and etc. Data received form thought experiment will be mapped to designed quality framework. This will give possibility of estimation of effectiveness of MOOC.

Students persona and his motivation.

Mr Franklin is a 24 year old Bachelor program student studying Business administration in Tallinn University of Technology with little bit of experience in computer programming. For existing moment he is finishing his Bachelor and in parallel working in Finance organization, oriented on offering of various loan products and financial services to developing countries. He found out about cryptocurrency topic during one of the courses while he was writing homework essay about alternative forms of currency. He was impressed and become enthusiastic about Bitcoin and underlying technology Blockchain and started to explore further this topic. After he gathered sufficient body of knowledge about technology he decide to study it fundamentals form the academic source for implementing this technology in one of the project at work. He researches about educational programs and luckily find out MOOC Course about blockchain tech offered in Moodle by Tallinn university.

Process of enrollment:

Franklin finds outs information about MOOC of blockchain tech on the web page of Tallinn

university. On the web page all sufficient information about features of the course is clearly presented. He reads about learning outcomes of the course curricula structure. Explores timelines of the course and overviews instructions about his future lecturers. He receive all the relevant information about interesting topics that MOOC is covering during studies.

After Franklin have sufficient information about future curse he decides to enroll in MOOC and clicks enrollment button. Web page of Moodle is opening and after login in Moodle he is enrolling in the MOOCs first course “introduction to concurrences”. He has experiences of using Moodle environment, because has previously taken few courses during bachelor studies and find Moodle very user friendly and easy to use.

After enrolling in the first course web page automatically displays starting page with introduction and instruction about issues regarding general structure of course, logistics, tasks and assessment issues. He also revises the message from instructor with welcoming words and main points important for studying process. Massage contains the link for survey to find motivation and educational and professional background of student.

First week

First week is starting with topic history of money. Topics covers development of money through different societies and understanding of nature of money and how cryptocurrencies are fitted in this definition. Course coordinator encourages participants to contribute on forum with creating link library and share interesting links around weekly topics. Studying materials consisting form youtube video lecture, where the lecturer presents core elements of the topic and presentation file, where all this elements are visualized. Franklin should answer multiple choice question based on video and presentation file and also participate in learning cell exercise. He watches video, which is 30 minutes in lengths and reviews presentation of the topic. After that he takes multiple choice quizzes. Additionally, Franklin participates in Active learning exercise, with peer student he forms the group and they generating questions around topic and posting them on forum for another group, also they have to answer on received questions from similar groups. After a while, he finishes his tasks and logs out from Moodle.

Second week

Second week's topic is about basics of bitcoin protocol. Topic describes the importance of the Byzantine General problem solved by bitcoin protocol and role of this solution in computer science. Studying approach are similar to first week. Franklin goes to enrolled course in Moodle and watches video lecture, after watching video he starts doing quiz. He participates in learning cell exercise with peer student and posts some question around the topic on forum in return they receive questions from different group. After that he logs out from Moodle. Soon he receives email from the instructor that opponent group have respond to the posted question and checks Moodle again to see answer. Few students are commented on question and he continues forum conversation with them. Franklin finds first two week very interesting materials are so far easy to follow and understand.

Third week

Topic for the third week is basic features of cryptocurrency. History of it's development and predecessor centralized versions of digital cash systems. Also topic includes initial introduction of bitcoin transactions and mining process. Task is to watch video lecture and presentations and accomplish multiple question and self assessment questions. Additionally course instructor have posted scheduled Q&A live session with one of the representation of P2P decentralized mining pool. He will overview mining process and hot topics in mining industry. One of the tasks for student is to prepare and post questions for live event, which takes place on weekends. Additionally, he participates in active learning exercise - think pair share. With his fellow student they discusses reading materials and answers on questions from assigned material. Franklin accomplishes all the task for third week and checks link library created on forum to see interesting reading shared by fellow students. He also adds his own links to library and prepares some questions for Q&A session.

Fourth week

Franklin starts fourth week with checking the link of Q&A live session. He watches Q&A session video and gets answers for his posted question from guest. After he goes in forum and checks activity and returns to the study area where materials for the fourth week is situated. Topic of the

week is practical issues regarding of send and receiving cryptocurrency with different online wallets and storing them using cold storage or paper wallets. He finishes video lecture for this week and moves to multiple choice questions. For the next week instructor gives group assignment to present ideal characteristics for cryptocurrency. Size of the group is 5 person (group is generated randomly by platform) and students have to conduct small research and deliver it on blog. Franklin looking forward to get in touch with future group members and enthusiastic to accomplish task.

5.3 Mapping of Thought experiment into proposed dimensions

1) Technology dimension

Technology dimension represented in thought experiment is a combination of synchronous and asynchronous learning process. Video lectures and presentation materials, also quizzes and self assessment tasks are asynchronous way of learning and Live Q&A question in third week is example of synchronous learning. Also it should me mentioned that Moodle is a cross platform learning environment so it can easily accessed from different platform such as computer, mobile or tablet. In conclusion technological dimension is strongly represented in thought experiment.

2) Pedagogy dimension

Main source of pedagogical dimension in thought experiment is video lectures accompanied with slides to support recursive learning. Videos are 30 minutes long recorded by lecturer generally in a classroom environment. In a thought experiment video lectures are followed by presentation slides consisting from compressed knowledge of facts and concepts reviewed during video lecture. After that retrieval learning technique is used with multiple choice questions. Finally self assessment questions are posted on forum by instructor for initiating discussions between students. During the fourth week of thought experiment group work project is conducted which is another pedagogical techniques to support collaboration and knowledge sharing between students.

3) Motivation dimension

Motivation dimension express how students are involved in learning and on other side how learning process is engaging students. Design of the weekly tasks in thought experiment are aimed to create sustainable knowledge transfer process, supported with active learning and also recursive learning

approach. Evident example of this is materials of video and presentation slides. The program designed to support linear knowledge transfer beginning from simple concepts and gradually exploring this concepts in depth creating bases for students to acquire step by step more complex theoretical and practical knowledge.

In thought experiment Franklin is highly motivated to learn discuss and reflect the topics presented in the course. He is following the course per week bases and masters his knowledge gradually. His motivation is also sustained by communication possibilities with peer students, lecturers and course assistant. Additional factor is certificate of accomplishment of the course, which plays important role for student motivation. Overall level of the dimension is medium.

4) Usability dimension

Moodle environment have all the necessary tools and elements to support learning process. The interface design is very minimalistic that supports intuitive navigation around the platform. There are also necessary tools to support collaboration and initiate various discussions using forum or online chat, in a same time it is also possible connect different types of web 2.0 tools to existing Moodle environment for widening communication perspective and bring additional source of knowledge into the learning process. Overall level of dimension is high.

5) Content/Material dimension

Content/material dimension is represented with multimedia tools using video lectures, Q&A live sessions utilizing Youtube or Google Hangout platform. Each week is new materials are given by lecturers and course instructor. Additionally students are contributing to creation of link library and sharing their own links about interesting topics and issues. Overall content/material dimension is strongly represented in thought experiment.

6) Support for learner dimension

In conducted thought experiment students have direct communication tools to ask further assistance or to give feedback. During all weeks course coordinator is very actively collaborating with students preparing and posting different self assessment questions on forum, presenting upcoming events for next week. Lecturer is also very responsive and have close communications with students in case of some questions. Overall dimension of learner support is strongly represented in MOOC.

7) Assessment dimension

Assessment dimension represented during the thought experiment is consisting from two types of assessment first is a multiple choice questions after each video lecture and presentation file and second is a self assessment which is linked to assessment of individual students asking them to reflect on some specific issues regarding current topic. Generally there are different types of assessment techniques used in proposed MOOC, which are not represented in thought experiment due to its limitations, such as peer assessment, final and midterm exams, group assignments and group projects. In summary assessment dimension is strongly represented in MOOC.

8) Future directions/Network's dimension

Future direction is not represented on thought experiment, but this dimension is realized with problem based learning approach which is implemented in some courses of the MOOC. Problem based learning approach will give possibility to gain theoretical and practical knowledge through solving the open ended real problem. This can be additional business model or monetization option for MOOC stakeholder’s. Companies and startups in Crypto 2.0 environment will introduce their actual problems and students will develop solutions for them. This will give students additional opportunity to realize their skills and find potential employment. Dimension of Future direction is represented on medium level in MOOC.

9) Collaboration dimension

Collaboration dimension is strongly represented in MOOC. This can be seen during all weeks in thought experiment. Franklin is easily communicating with instructor, lecturer and peer students using online chat or forum. Engagement and collaboration of students are also supported with different task during group works, Q&A sessions. Instructor has proactive role and informs about all the important tasks and events for the next week. Also there are possibilities to use social media tools to to bring additional viewpoints and discussion topics into the forum environment.

Dimension	Low	Medium	High
Technology			X
Pedagogy			X
Motivation		X	
Usability			X
Content/Material			X
Support for learners			X
Assessment			X
Future direction/Network's		X	
Collaboration			X

Figure 16. Ranking of dimensions for evaluation.

Figure 16 show summarization of all dimension based on thought experiment. This dimensions are main constituent part for providing effective learning experience for MOOC. All the dimensions in thought experiment are represented on a high level except motivation and Future direction/networks which are represented on medium level.

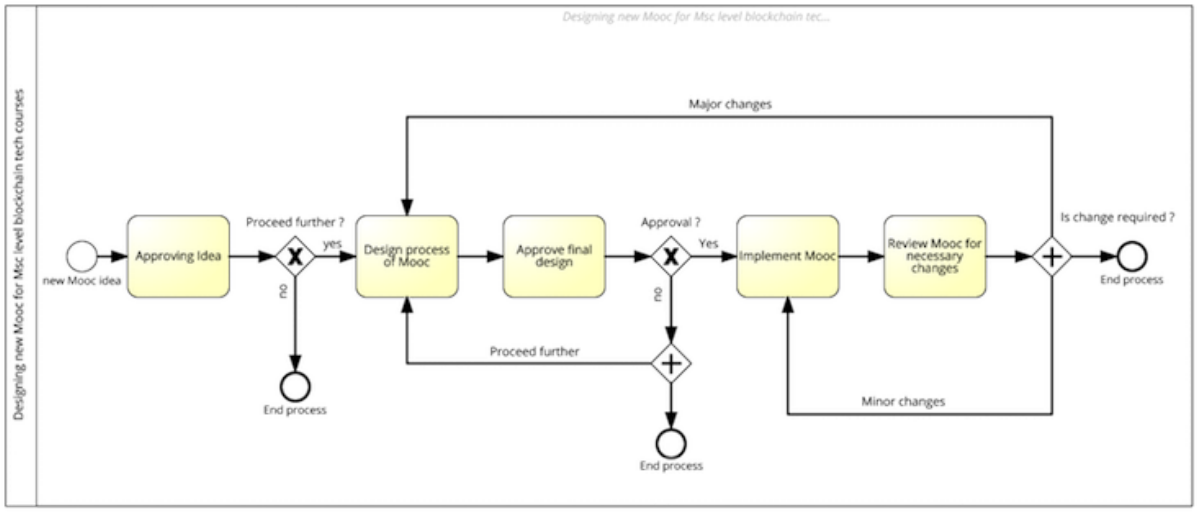

Figure 17. design and improvement stages of the MOOC from faculty perspective.

Additionally it is necessary to present entire process of MOOC design, implementation and evaluation of the MOOC form faculty perspective to underline different stages to consider in implementing proposed MOOC.

Presented above figure 17, BPM diagram shows wider picture of designing, implementing and evaluating process from the faculty perspective. There are five stages, first stage is an idea proposition. Second stage is MOOC designing process, which is initiated if first stage in approved by faculty. After having complete finial design, MOOC goes to approval process. In case of approval process of implementation starts, otherwise it is going back to design stage to make necessary improvements. Fourth stage is implementing stage and finally reviewing stage were once again MOOC is evaluated for effectiveness for necessary minor or major changes. In case if faculty did necessity of changes process stops and learning process continues as designed.

6. Conclusion and future work

Final chapter concludes research efforts of the theses and outlines directions of future work. Thesis constructed the conceptual framework for designing a MOOC for Teaching a MSc-Level Blockchain-Tech Course. Developed framework of MOOC facilities effective teaching of Blockchain technology from holistic view considering intersection of various discipline such as computer science, ICT, finance, management ect. Outcome of the work is multi-media driven MOOC, which incorporates best practices and tools of online learning to effectively transfer knowledge about theoretical and practical implications of Blockchain technology to future students.

The research in this thesis is backed up with the theoretical approaches covering the concepts of learning theories, MOOCs and their development frameworks and the best practices of curriculum engineering. Author explores timeline of development basic concepts and elements of MOOC, suitable design frameworks for developing course curricula and for MOOC design. With combining this frameworks author generates curriculum of Blockchain course and populates it with constituent courses. Also presents pedagogical approaches considering constructivist learning theories and active learning strategies, along with tools and features based on the best online learning practices. Next author continues with proposing appropriate MOOC platform based on previous findings and

finally evaluates proposed MOOC for Blockchain tech, with conducting thought experiment and mapping this thought experiment in proposed framework for evaluation of MOOC effectiveness.

Future work

Thesis leaves many unanswered questions, acknowledging aforementioned next step will be to answering this questions by presenting software prototype of the MOOC. Additionally there are vast areas for future exploration considering rapid progress in educational technologies.

There are various interesting areas for further exploration such as integration of learning analytics to capture and analyze interaction patterns inside the MOOC platform between different MOOC participant. Reach data about this interactions can used to determine patterns of learning and teaching and adjust pedagogical strategies to maximize effectiveness of the learning. Also from automatization perspective it would be very interesting to explore adaptive learning concept, based on knowledge, competencies and interest of student, offer them personalized learning path.

Badges and blockchain

Blockchain technology offers new unexplored ways for accreditation and certification options (example OTLW or BadgeChain). Additional interesting direction fro future work will be using blockchain technology as a ledger for information management for recording archived results, certificates, badges or nano degrees and create different type of right management options for various parties interested in this results.

Finally and most important and interesting direction of future work will be how to build DAO (decentralized autonomous organization) for blockchain technology learning. DAO will represent concept of platform for learners and teachers. Rough conceptualization of DAO for blockchain learning will have properties mentioned below: It will track via points or badges, all the learning that student have realized in particular field. Each unit will be equal of one hour learning of specific topic. Platform will issue credentials based on precise mechanism for capturing and representing all

the learning inside and outside the educational platform. Profile of the student can share some specific information requested by future employ for offering a job or suggesting team member that matches student's competence. Because DAO is using transactional capabilities of blockchain technology, it can track future income of the student and based on that offer valuable information for other students who are deciding, which profession to master. DAO also can exploit smart contracts to create agreements between students and investor. Investor will be able to invest in students education on exchange of future income. In a high level of abstraction it can be the initial thinking point how to decentralize education.

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