Blockchain curricula for teachers and trainer

IO2

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BLOCKS - Blockchain for Entrepreneurs - a non-traditional Industry 4.0 curriculum for Higher Education

This document was created by the team members of Erasmus+ Strategic Partnership project *"BLOCKS - Blockchain for Entrepreneurs - a non-traditional Industry 4.0 curriculum for Higher Education" - 2018-1-RO01-KA203-049510*.

Key Ideas

Teaching (about) the blockchain is a challenge, as

- The technology is in **rapid growth**,
- There is **little teaching material structured** in a manner that is suited to higher education
- The knowledge relies significantly on **use cases**
- There is little effort towards significant **critical thinking regarding the technology**
- There is a **lack of common vocabulary** between tech and non-tech professionals
- There is **no clear, mainstream use case** for the blockchain to prove indubitably its usefulness, therefore each case must be treated critically
- There are **no clear, definite returns** (particularly monetary) returns regarding the blockchain
- There is a certain **overhype** of the technology - causing increasing interest, but also polarisation
- The conversation is often niched towards **cryptocurrency**

Knowledge to be developed regarding the blockchain

For teachers and trainers

Blockchain is about
Trust
Technology
Cryptography
Governance

Basic principles for developing a curriculum

For teachers and trainers

Curriculum most likely would have to be created in **modules** so each module can be independent from each other and combined for specific target groups needs.

Modular curriculum also would be easier to use for trainers and teachers and adjust these materials to their study process. There should be **study cases** in each module together with theory involved.

Curriculum should be made about the blockchain technology topics.

Gamification should be taught to teachers and trainers for a better deployment of study materials.
The BLOCKS platform allows for gamification and **interactivity** in the provided study materials via the H5P feature.

Curriculum for teachers and trainers should have a strong component of **critical thinking** (to be implemented via using the Socratic method) regarding the blockchain - as a tool to question current societal issues / current societal structure / the current social contract.

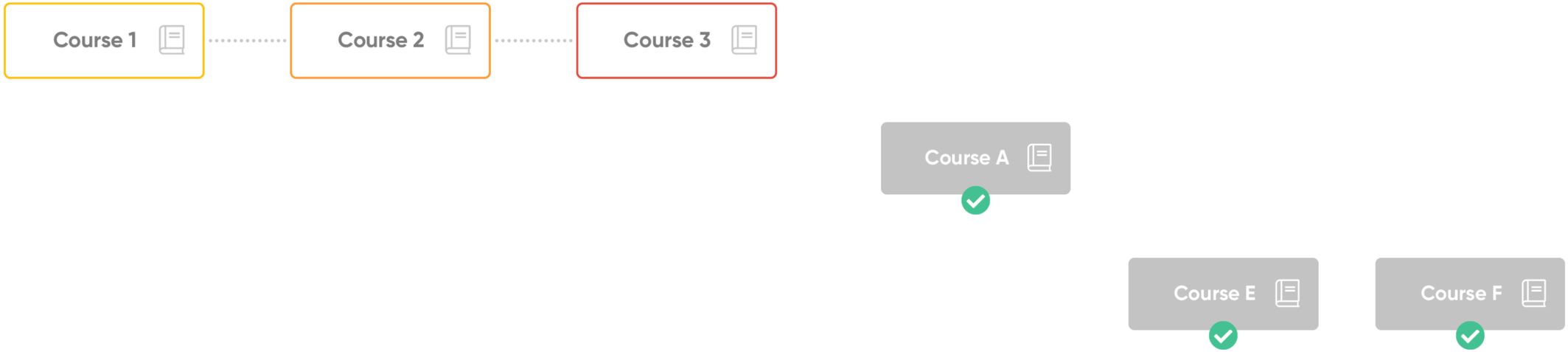
Out of the box elements to be included - use art, music, texts analogies which are relevant to the topic, but take the blockchain conversation outside the programming dialogue.

Learning paths

A tool to be used for teachers, trainers, students and entrepreneurs

A **learning path** is
”a selection of courses tied together for learners to progress through, mastering a particular subject or program”.

Learning paths may be **predetermined** or **allow for the user (student) to choose**.



Source: LearnUpon Blog - https://www.learnupon.com/blog/learning-paths-walkthrough/

Using learning paths to teach about the blockchain

For teachers and trainers

Different learning paths (allowing the user to choose the course) should be created for teachers teaching tech topics vs teachers teaching non-tech topics.

Non-tech teachers should be allowed to have a less programming-intensive learning path.
Tech teachers should be allowed to have a deep-dive in the matters related to implementation of the blockchain.

All teachers are considered as advanced users, even if they are provided with introductory courses.
They are aware of modularisation / are able to grasp complex concepts easily.

Paths to knowledge

For teachers and trainers

Section1: Introduction
-blockchain network, nodes and virtual machines
-transactions, blocks and block headers
- blockchain Consensus mechanisms (PoW)
-introduction to smart contracts(Solidity)

The topics section 1 are necessary in understanding the blockchain technology and its suitable for the students and beginners.

Section2: Blockchain application areas and reasons for adoption
-top blockchain application areas

The topics in section 1 and 2 good for understanding the technology and its application in the industry. This is suitable for entrepreneurs.

Section 3: Blockchain limitations
-Critical blockchain limitations
-less important blockchain limitations

The topics in section 1,2 and 3 are good for the teachers to provide the basic knowledge, application and limitations of blockchain technology.

Section 4: Research directions in addressing critical blockchain limitations

For researchers and developers, topics 1,2,3,4 are necessary in understanding the trends and latest development that addresses existing blockchain limitations.

Layers of use cases

Blockchain applications

Learning paths -
modular courses to be created for use cases.

For instance, a finance professor may be interested just in the applications of the blockchain for financing.

Bloom’s Taxonomy

To design learning objectives and outcomes

The complexity of the learning objectives and outcomes, the expected outcomes and target audience of the curriculum are arranged with the help of the useful tool of Bloom’s taxonomy.

Benjamin Bloom developed the corresponding taxonomy in 1956. The list of goals and expected outcomes that the instructors want to achieve through the learning process are depicted in the next page.

The complex framework of this taxonomy is used to connect learning objectives, techniques and assessments to achieve the overall goals. (Source> Anderson, Lorin W.; Krathwohl, David R., 2001)

Bloom’s taxonomy is hierarchical in nature and learning commences with a low level of knowledge and skills and gradually advances to higher levels of knowledge and skills.

Table 1:Blooms' Taxonomy.

Lower-Order	**1.** Remembering: Retrieving, recognizing and recalling relevant knowledge for long-term memory **2.** Understanding: Constructing meaning from oral, written and graphic messages through interpreting, exemplifying, summarizing and explaining. **3.** Analyzing: 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 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

Skills and competences related to a blockchain course

For teachers and trainers

KNOWLEDGE	SKILLS
1. Knowledge of an area of specialization and, within it, of the theoretical, methodological and practical developments specific to the program; appropriate use of specific language in communication with different professional environments	Identification and in-depth description of blockchain concepts and theories
The use of specialized knowledge for explaining and interpreting new situations, in broader contexts associated with the field	Development of concrete arguments for the interpretation of real situations that involve the use of blockchain technology
ABILITIES	
Integrated use of the conceptual and methodological apparatus, in conditions of incomplete information, to solve new theoretical and practical problems	Identify strategies applicable to real complex situations, in the context of digital transformation using blockchain technology
The nuanced and pertinent use of evaluation criteria and methods to formulate value judgments and substantiate constructive decisions	Formulation of solutions for real complex business situations, using integrated techniques and procedures, in the context of digital transformation using blockchain technology
Development of professional and / or research projects, innovatively using a wide range of quantitative and qualitative methods	Elaboration of a digital transformation project suitable for complex real situations using blockchain technology
Minimum performance standards for competency assessment:	*Elaboration of a project of substantiation and implementation in an organization of a digital transformation strategy using blockchain technology*

Substantiation and implementation of digital transformation strategies using blockchain technology in an organization

Short-term programme for tech teachers

A curriculum

Based on Bloom's Taxonomy, a curriculum is designed for a
Summer School comprising of 3 ECTS with 12 modules.

The modules were taught during the
summer school with vast diversity of attendants from different professionals and age group and
the corresponding evaluation of the curriculum is conducted.

The short-term programme is designed while keeping in view the sociotechnical domain of blockchain technology and its applicability in different disciplines such as finance, commerce, computer science, ICT, cryptography, distributed systems, cybersecurity, systems scalability, new innovative business models and startup culture and so on.

The objective of the short-term programme
is to prepare professionals benefiting from their diverse and broad backgrounds and
to provide a holistic analysis of blockchain technology, smart contracts, and digital currency systems, applications and services.

Moreover, the short-term programme is also prepared to develop a solid understanding of abstracting the essential structure, recognizing
the sources of uncertainty and applying appropriate state of art models and technical tools from
blockchain environment to develop different solutions for the market.

Basic Modules	1.25 ECTS
Advance Modules	0.5 ECTS
Specialist Modules	1.25 ECTS

BASIC MODULES:

Module 1: Blockchain Cryptography Basics

Module	Blockchain Cryptography Basics
Lecturer	
Language	English
Teaching Method	Lecture + practical exercises
Credit Points / Duration	0.25 ECTS / 4 Lectures of 90 minutes each
Attendance Requirements	Some basic math skills
Goals / Skills	Blockchain technologies make heavily use of cryptography to achieve a consensus, be it in a Proof-of-Work or Proof-of-Stake protocol as in Bitcoin or Ethereum. In order to understand the key principals behind the protocols, we explore the magic behind hash functions and digital signatures. Specifically, we dive into the mechanics of Elliptic Curve DSA (ECDSA) and the Keccak hash function family. The students will not only learn how the cryptographic primitives work but also understand why they are secure.

Content	1. A short intro to Blockchain 2. Motivation for Hash Functions/Signatures 3. Math Basics (Groups, Elliptic Curves) 4. ECDSA 5. Keccak Hash Family
Media Used	Electronic presentation, blackboard illustrations, discussion, practical exercises
Suggested Reading	Jonathan Katz and Yehuda Lindell: Introduction to Modern Cryptography (2nd Edition)

Module 2: Blockchain and Consensus

Module	Blockchain and Consensus
Lecturer	
Language	English
Teaching Method	Lecture
Credit Points / Duration	0.25 ECTS / 4 Lectures of 90 minutes each
Attendance Requirements	Basics in computer science and mathematics; Some background in distributed algorithms is helpful
Goals / Skills	The students will learn about centralized, distributed and probabilistic consensus algorithms. They will understand why traditional, deterministic algorithms are not feasible for large scale networks and will understand the need for additional conceptual extensions for a scalable consensus. They will obtain a basic and conceptual understanding of how cryptocurrency technologies can overcome these limitations and how consensus is the core computational primitive at the root of Bitcoin, Ethereum, IOTA and other recent developments.
Content	1. Deterministic consensus algorithms. 2. Limitations from complexity and Brewer's theorem. 3. The gist of the Nakamoto Bitcoin and of the Popov Tangle White Paper 4. Advanced consensus technologies 5. Concepts of blockchains, proof-of-work, and tangle
Media Used	Electronic presentation, blackboard illustrations, discussion, practical demonstrations
Suggested Reading	• Satoshi Nakamoto: Bitcoin: A Peer-to-Peer Electronic Cash System • Serguei Popov, The Tangle. • Shreya Agrawal, Khuzaima Daudjee: A Performance Comparison of Algorithms for Byzantine Agreement in Distributed Algorithms • Leslie Lamport, Robert Shostak, Marshall Pease: The Byzantine Generals Problem • Seth Gilbert, Nancy Lynch: Brewer's Conjecture and the Feasibility of Consistent, Available, Partition-Tolerant Web Services

Module 3: Basics of Smart Contracts and Creation of New Tokens

Module	Basics of Smart Contracts and Creation of New Tokens
Lecturer	
Language	English
Teaching Method	Lecture + Tutorial
Credit Points / Duration	0.25 ECTS / 4 Lectures of 90 minutes each
Attendance Requirements	Basics in computer science and software engineering; blockchain basics
Goals / Skills	The students will learn about the underlying principles that are required to create blockchain-based smart contracts. They will understand why such smart contracts are better than currently prevalent means of creating contracts and to create exemplary smart contracts for various applications, especially those that involve machine-to-machine and IoT based communication. Moreover, with the rising popularity of ICOs, the students will learn how new tokens can be created on the Ethereum ecosystem. As a result of this course, the students will be equipped to evaluate as well as create smart contracts for a wide range of use-scenarios and create their own tokens when required.
Content	1. Smart Contracts Basics 2. Establishing Our Own Private Ethereum Network 3. Smart Contracts on Solidity 4. Creation of new tokens using ERC20 5. Analysis of Use Case Feasibility
Media Used	Electronic presentation, blackboard illustrations, discussion, practical exercises
Suggested Reading	• Satoshi Nakamoto: Bitcoin: A Peer-to-Peer Electronic Cash System Dmitry Khovratovich et al.: SecureToken Development and Deployment • K Delmolino et al.: Step by step towards creating a safe smart contract: Lessons and insights from a cryptocurrency lab • K Christidis et al.: Blockchains and smart contracts for the internet of things • GW Peters et al.: Understanding modern banking ledgers through blockchain technologies: Future of transaction processing and smart contracts on the internet of money

Module 4: Initial Coin Offerings (ICOs) – Crowdfunding on the Blockchain

Module	Initial Coin Offerings (ICOs) – Crowdfunding on the Blockchain
Lecturer	
Language	English
Teaching Method	Lecture + practical exercises
Credit Points / Duration	0.25 ECTS / 4 Lectures of 60-90 minutes each
Attendance Requirements	Basics in computer science and mathematics; blockchain basics

Goals / Skills	This lecture focuses on so-called initial coin offerings (ICOs) – a novel approach for crowdfunding of blockchain startups. The students will learn and understand the disadvantages of existing funding approaches and the advantages and challenges of ICOs as an alternative finance instrument. Furthermore, different strategies on how to conduct an ICO as well as analyses of successful and failed real-world ICOs will be conducted. As a result of this course, the students will obtain an understanding of the basic concepts of ICOs, issues of different conceptual approaches to ICOs as well as the advantages of blockchain-based solutions.
Content	1. Traditional start-up funding approaches 2. Fundamentals of ICOs 3. Different strategies and approaches to conduct an ICO 4. Create your own token on the blockchain 5. Analyses of successful and failed ICOs
Media Used	Electronic presentation, blackboard illustrations, discussion, practical exercises
Suggested Reading	• Satoshi Nakamoto: Bitcoin: A Peer-to-Peer Electronic Cash System • Gavin Wood: Ethereum: A Secure Decentralised Generalised Transaction Ledger • Christian Catalini, Joshua S. Gans: Initial Coin Offerings and the Value of Crypto Tokens • John P. Conley: blockchain and the Economics of Crypto-tokens and Initial Coin Offerings

Module 5: Blockchain and the Law

Module	Blockchain and the Law
Lecturer	
Language	English
Teaching Method	Lecture
Credit Points / Duration	0.25 ECTS / 4 Lectures of 90 minutes
Attendance Requirements	Basics in computer science and mathematics
Goals / Skills	The students will learn about the legal implications of blockchain-based transactions, reaching from controversies about the forming of contracts (declaration of intent), accountability, representation, and liability for non-performance. Students will obtain basic skills and knowledge to identify legal requirements to be taken into account when setting up blockchain-based transaction systems, and they will gain awareness of liability risks and provided procedural measures to cope with them.
Content	1. Formation of contracts in civil law and common law systems 2. A mistake in contract contents and its impact 3. Non-performance of contracts and legal remedies

	4. Interpretation of blockchain-generated contracts under European private law 5. Smart contracts and restricted legal capacity 6. Outlook: Accountability challenges of contracts concluded by autonomous systems
Media Used	Electronic presentation, blackboard illustrations, discussion, practical demonstrations
Suggested Reading	Primavera De Filippi, Aaron Wright: blockchain and the Law, Harvard University Press 2018, ISBN 9780674976429

ADVANCE MODULES:

Module 6: Authentication and Digital Identities on the Blockchain

Module	Authentication and Digital Identities on the Blockchain
Lecturer	
Language	English
Teaching Method	Lecture
Credit Points / Duration	0.25 ECTS / 4 Lectures of 90 minutes
Attendance Requirements	Basics in computer science and mathematics; blockchain basics
Goals / Skills	This lecture focuses on digital identities and blockchain-based authentication solutions. The students will learn and understand the challenges of digital identities and issues of existing (de)centralized authentication and identity solutions. As a result of this course, the students will obtain an understanding of the basic concepts of digital identities, issues of different conceptual approaches to digital identities as well as the advantages of blockchain-based solutions.
Content	1. Digital Identities 2. Challenges and limitations of digital identities 3. Existing (de)centralized authentication systems and their limitations 4. (Self-Sovereign) blockchain-based Identity solutions
Media Used	Electronic presentation, blackboard illustrations, discussion, practical demonstrations
Suggested Reading	• Satoshi Nakamoto: Bitcoin: A Peer-to-Peer Electronic Cash System • Christian Lundkvist: uPort: A Platform for Self-Sovereign Identity • Guy Zyskind: Decentralizing Privacy: Using Blockchain to Protect Personal Data • Guy Zyskind: Enigma: Decentralized Computation Platform with Guaranteed Privacy • Authcoin

Module 7: Business Process Management (BPM) and Blockchain

Module	Business Process Management (BPM) and Blockchain
Lecturer	
Language	English
Teaching Method	Lecture and practical exercise
Credit Points / Duration	0.25 ECTS
Attendance Requirements	Basic understanding of computer science and business administration
Goals / Skills	The students will get essential concepts of business process management and the way how they can be supported by blockchain concepts. The focus of the module is the concepts of business process management and their blockchain support. The goal is to enable students to specify business processes with BPM and to translate them into blockchain concepts.
Content	1. Essentials of business process management 2. Modeling business processes with BPMN 3. Business process management systems 4. Blockchain support of business processes
Media Used	Electronic Presentation, Blackboard Illustrations, Practical exercises by the students
Suggested Reading	Dumas, La Rosa, Mendling, Reijers: Fundamentals of business process management. 2nd Edition, 2018.

SPECIALIST MODULE:

Module 8: Blockchain and Privacy

Module	Blockchain and Privacy
Lecturer	
Language	English
Teaching Method	Lecture + Tutorial
Credit Points / Duration	0.25 ECTS / 4 Lectures of 90 minutes each
Attendance Requirements	Basics in computer science, mathematics, and blockchain; A background in cryptography is helpful.
Goals / Skills	The privacy of blockchain participants and the confidentiality of on-chain data are an underestimated problem in most current blockchain implementations. If not addressed properly, many proofs-of-concept will not have the possibility to mature into production. Legacy blockchain implementations like Bitcoin rely on all the transaction data being stored in plain text on the blockchain for them to be validated by the network.

	This lecture will highlight the false promises of pseudo-anonymity, why most current blockchains offer the opposite of privacy and current solutions to the identified problems.
Content	1. Off-chain storage, side-chains, state channels (lightning, perun, raiden, ...) 2. Address deriving schemes 3. 1-time payment addresses 4. stealth addresses 5. zk-SNARKs 6. mixing
Media Used	Electronic presentation, blackboard illustrations, discussion, practical exercises
Suggested Reading	• Vitalik Buterin: Privacy on the blockchain (Ethereum Blog) • Ahed Kosba et al.: Hawk: The Blockchain Model of Cryptography and Privacy-Preserving Smart Contracts • Guy Zyskind et al.: Enigma: Decentralized Computation Platform with Guaranteed Privacy • Ian Miers et al.: Zerocoin: Anonymous Distributed ECash from Bitcoin • R3 research: Survey of Confidentiality and Privacy-Preserving Technologies for Blockchains • CryptoNote Whitepaper (now Monero, uses Ring Signatures for Privacy)

Module 9: Advanced Module on Smart Contracts

Module	Advanced Module on Smart Contracts
Lecturer	
Language	English
Teaching Method	Lecture
Credit Points / Duration	0.25 ECTS / 4 Lectures of 90 minutes each
Attendance Requirements	Basics in computer science and mathematics; Some background in distributed algorithms is helpful
Goals / Skills	The students will learn about the state of the art in three specific aspects pertaining to smart contracts. First, the students will learn about problems of oligopoly formation in proof-of-stake formation and mitigation with the use of mobile smart contracts. Next, the current state of the art of smart-contract languages with their pros and cons will be explored. Finally, we move from intra-organizational smart contracts to cross-organizational smart contracts and explore how an additional multi-agent system layer on top of smart-contracts helps to facilitate collaboration.
Content	1. Proof of stake problems and mobile smart contracts 2. Pros and cons of currently existing smart-contract languages 3. Cross-organizational collaboration models for legally relevant smart contracts

	4. Multi-agent-systems to facilitate cross-organizational smart-contracts collaboration 5. Advanced cross-organizational topics such as conflict management, e-governance, rollbacks of collaborations.
Media Used	Electronic presentation, blackboard illustrations, discussion, practical demonstrations
Suggested Reading	The students will get a list of specific research papers for each topic.

Module 10: Legally Intended Smart Contracts

Module	Legally intended Smart Contracts
Lecturer	
Language	English
Teaching Method	Lecture and practical exercise
Credit Points / Duration	0.25 ECTS
Attendance Requirements	Required: Foundations of object-oriented programming Advantageous: Basic understanding and terminology of contract law; Basics of smart contract operation on blockchains
Goals / Skills	The students shall understand the interaction between law and the design of legally intended smart contracts. The students will learn about design challenges, pattern and modeling tools. The focus of this module in on teaching the complexity of understanding legal terms and transferring them into code considering legal frameworks. The goal is to understand the need for close cooperation with lawyers to write correct legal code. Additionally, the student shall learn about modeling techniques and tools for legally binding code.
Content	1. Introduction into basic legal terminology and processes by the example of a simple sales and delivery contract 2. Development of legal primitives (atomic elements) and transfer into programmable objects; learning using modeling tools 3. Analysis of an existing legally binding smart contract regarding the elements above 4. Design of a new (simple) legally binding smart contract
Media Used	Electronic presentation, live programming lecture, literature and code analysis, programming exercise
Literature	Grigg, I.: The ricardian contract. In Proceedings of the First IEEE International Workshop on Electronic Contracting, pages 25–31. IEEE, 2004. http://iang.org/papers/ricardian_contract.html Grigg, I.: On the intersection of ricardian and smart contracts, 2015. http://iang.org/papers/intersection_ricardian_smart.html https://docs.accordproject.org/docs/accordproject.html https://www.gesetze-im-internet.de/englisch_bgb/

Assigned Tutorial	The students will interpret a very short legal contract, convert it into a coding model, code it and deploy it on a blockchain
Suggested Reading before the start of the summer school	• C. D. Clack, V. A. Bakshi, und L. Braine, "Smart Contract Templates: essential requirements and design options", 2016. • R3 and Norton Rose Fulbright. Can smart contracts be legally binding contracts? 2016. http://www.nortonrosefulbright.com/knowledge/publications/144559/can-smartcontracts-be-legally-binding-contracts/

Module 11: DLT Lab – Practical Exercises

Module	DLT Lab – practical exercises
Lecturer	
Language	English
Teaching Method	Lecture and practical exercise
Credit Points / Duration	0.25 ECTS
Attendance Requirements	Required: Basics of blockchain technologies – esp. Ethereum Advantageous: Basics of smart contract operations on blockchains
Goals / Skills	The student shall practice the development, deployment, and operation of smart contracts. The focus of this module is on gaining practical abilities for the development of smart contracts. The goal is to be able to design and to develop smart contracts in Ethereum using solidity.
Content	1. View Information on Bitcoin and Ethereum 2. Use Metamask to Send and Receive Tokens from the Browser 3. Develop owner- and addressee-sensitive smart contracts 4. ERC20-contract 5. Develop a Hyper Ledger Fabric smart contract
Media Used	Electronic presentation, active programming

Module 12: Blockchain: A Decentralized Political Technology

Module	Blockchain: A Decentralized Political Technology
Lecturer	
Language	English
Teaching Method:	Lecture
Credit Points / Duration	0.25 ECTS / 4 Lectures of 90 minutes each
Attendance Requirements	Basics in computer science, Austrian School of Economics; Blockchain basics; Crypto Anarchy; Knowledge about previous Cryptocurrencies
Goals / Skills:	This lecture focuses on explaining the origin and original use of Blockchain. The students will understand and argument if blockchain originates in Political economy.

Blockchain technology for business development

for teachers and trainers

Aim and tasks of the course

The aim of this course is to prepare teachers for work with a new course “Blockchain technology for business development”.

Teachers will inform students about the safety methods of blockchain technology data storing and processing, develop new competencies necessary to estimate whether to use on blockchain technologies-based e-solutions and evaluate possible benefits for business.

After completing this course participants will be able to teach “Blockchain technology for business development” course, as well as participate in development and implementation of blockchain technologies-based solutions in different occasions.

Blockchain technology for business development

for teachers and trainers

Target audience for the course

Teachers and trainers of training centres, K12 and vocational schools, who are going to teach “Blockchain technology for business development” course or integrate blockchain technology topics into their courses.

Blockchain technology for business development

for teachers and trainers

Requirements regarding education and experience related to the field of the course (preliminary knowledge level starting the course)

Students of the course will acquire competencies regarding blockchain technology, including knowledge on technology basics, solutions based on this technology and knowledge about teaching blockchain technology topics.

Participants of this course are required general teaching skills, basic computer skills and basic English language knowledge.

Blockchain technology for business development

for teachers and trainers

Requirements regarding education and experience related to the field of the course (preliminary knowledge level starting the course)

Students of the course will acquire competencies regarding blockchain technology, including knowledge on technology basics, solutions based on this technology and knowledge about teaching blockchain technology topics.

Participants of this course are required general teaching skills, basic computer skills and basic English language knowledge.

Co-funded by the
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Blockchain technology for business development for teachers and trainers

1. Aim and tasks of the course

The aim of this course is to prepare teachers for work with a new course "Blockchain technology for business development". Teachers will inform students about the safety methods of blockchain technology data storing and processing, develop new competencies necessary to estimate whether to use on blockchain technologies-based e-solutions and evaluate possible benefits for business. After completing this course participants will be able to teach "Blockchain technology for business development" course, as well as participate in development and implementation of blockchain technologies-based solutions in different occasions.

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Teachers and trainers of training centres, K12 and vocational schools, who are going to teach "Blockchain technology for business development" course or integrate blockchain technology topics into their courses.

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Students of the course will acquire competencies regarding blockchain technology, including knowledge on technology basics, solutions based on this technology and knowledge about teaching blockchain technology topics. Participants of this course are required general teaching skills, basic computer skills and basic English language knowledge.

4. Course length, hours

	Number of hours (academic hours)		
	Lectures/Theory	Hands-on activities/Practicum	Overall
Onsite classes:	8	8	16
Online study:	8	8	16
Total number of hours:	16	16	32

5. Course content

No.	Desired result – after finishing the course, the participant will be able to:	Topic	Sub-topic	Overall number of hours **(academic hours)**
1	• Explain, what is blockchain and what kind of problems can be solved using	Introduction to blockchain technology.	• What is blockchain? Myths and truth about blockchain; • Why world needs a blockchain technology and what problems can it solve?	6

	blockchain technology; • Evaluate and compare blockchain technology benefits with its disadvantages.		• Benefits and disadvantages of blockchain technology; • How should we prepare students today for a future world governed by cryptocurrency and blockchain? • What is the new philosophy/ideology and psychology of blockchains that will give you a competitive edge in the new crypto/blockchain world? • Further education on Blockchain topics: competences and development tracks, Blockchain education in Latvia, EU and globally.	
2	• Compare and analyse examples of blockchain technology application in different industries; • Describe how blockchain technology can influence and/or change different industries	Analysis of examples from blockchain technology application (case studies).	• Blockchain technology in different industries - financial services, media and entertainment, food supply, government and public services, healthcare, real estate; • How blockchain technology can influence and change industries? • Benefits of blockchain technology in different industries (fields).	6
3	• Explain, how blockchain technology protects our data from counterfeiting; • Explain the meaning of distributed database, HASH functions, blockchain fork and describe how blockchain technology provides data integrity.	How blockchain technology works and how can it be used in data protection and storing?	• How blockchain technology protects our data from counterfeiting? What is distributed database, HASH function, blockchain fork and how blockchain technology secures data integrity? • What is digital identity and how you can prove your identity in digital world (e-signature and alternatives)? • The reason consensus is important in blockchain technology, ways to get consensus in digital environment. • How can educators confidently introduce crypto/blockchain to students when most people do not really understand it and what tools are available to them now to help them?	8

4	• Explain what are the differences between fiat money, digital currencies and cryptocurrency; • Explain, what is cryptocurrency and how it works; • Describe what is Bitcoin; • Explain what is mining and what are miners doing; • Evaluate usefulness of the mining; • Analyse differences and specifics of the most popular cryptocurrencies.	Cryptocurrency and decentralised payments. What is Bitcoin?	• What is cryptocurrency and how it works? • What is Bitcoin? • What is mining and what are miners doing? • What kind of cryptocurrencies exist, what are their specifics and what are the differences between them. Overview about the most popular cryptocurrencies. • Safe payments with cryptocurrency, digital wallet, digital wallet types and usage. • How to buy cryptocurrency - stock exchanges and other sources. • Cryptocurrency price - how cryptocurrency exchange rate is set. • How can we protect beginners that dabble in cryptocurrency from fraudsters and other nefarious entities that might take advantage of them? • How can teachers build fun, safe, crypto communities for students to learn about (and experiment with) crypto?	6
5	• Explain what is Smart contract and how it works; • Evaluate benefits from implementing and using Smart contracts; • Analyse business processes and evaluate the necessary changes in existing business processes to use Smart contracts; • Organize preparation of the Smart contract and its implementation.	What is Smart contract?	• History of Smart contracts; • How Smart contracts work? • How to assess business benefits from Smart contact implementation - analysis of existing business processes and transformation needed in order to use Smart contracts; • How is Smart contract prepared and implemented? • What are Smart contracts currently being used for.	6

6. Technical support required for the course

Training class are equipped with stationary and/or portable computers. Number of computers depends on the number of training participants. Interactive board, projector, printed learning book, electronic training materials and tasks in online training system.

7. Evaluation of the course (examination)

An online test after the course about course topics in order to evaluate the course and participant knowledge level. Test is based on competency approach and evaluates competencies.

8. Training methods used to carry out the course

Educational program includes both onsite classes and online study.

Training methods used during onsite class:

- lectures and presentations – in order to maintain participant focus, lecturers verbal part is divided in 10-minute blocks. To reduce lecture monolog format flaws to memorize the material, lecturer uses examples. That helps participants to draw parallels with their daily responsibilities and discover opportunities for improvements in their business processes. Lecturer is practicing involving the audience, asks questions and asks participants for their opinion;
- educational games – in order to understand some processes of Blockchcain technology better, students could be enrolled into simulation games, where they play the role of a computer making some calculations and transactions;
- lecture material is visualized with different presentation techniques – presentation slides with lecture key points, videos to illustrate examples from presentation, etc.;
- work in groups – every part of the lecture includes practical application of gained knowledge, so that participants would be able to start using it right after the lecture. Group work includes assessment and discussions part. This helps participants to get feedback and helps them to learn from their own and other mistakes. It could minimize errors in their everyday work.

Knowledge, gained in online study part, will be strengthened with following methods:

- discussions and analysis about the situations – this course include several practical examples to form skills that will help to choose the most effective approach for professional work;
- independent tasks in online training system for distance learning;
- materials from lecture and presentation in online system for distance learning;
- test to evaluate knowledge and skills – at the end of the course participants will take an online test. Test results will be available for each participant and for lecturer. Test is based on scenarios and developed according to competency approach. This shows and allows to evaluate participant theoretical knowledge level and whether the participant can use this knowledge in everyday work situations.

9. Bibliography

1. How to Learn About Blockchain If You Didn’t Study Computer Science [https://media.consensys.net/heres-how-to-learn-about-blockchain-when-you-re-not-technical-71aa7a86816a];

2. Guide: An Introduction to Encryption [https://media.consensys.net/guide-an-introduction-to-encryption-9afd17f5da6d];
3. Learn Blockchains by Building One [https://hackernoon.com/learn-blockchains-by-building-one-117428612f46];
4. The Blockchain Game [https://www.instructables.com/id/The-Blockchain-Game/];
5. 10 Cool Ways to Use Blockchain in School [https://vocal.media/theChain/10-cool-ways-to-use-blockchain-in-school];
6. Blockchain For Dummies®, 2nd IBM Limited Edition [https://www.ibm.com/downloads/cas/36KBMBOG];

Master programme in blockchain

for teachers and trainers

The purpose of the course is to produce Master level graduates that have a systematic overview of the relationship between blockchain and ICT; basic concepts, theoretical principles and research methods of the field.

The graduate should also analyze, model, plan and apply blockchain solutions needed for reorganizing financial management and computer science processes and create new developments as well.

Additionally, students with interest in farther research can continue with their interest in doctoral studies.

Program Requirement: Completion of 90 ECTS credit, included general studies, special studies, core studies.
Master's Degree Title: Blockchain and Smart Contracts
Duration: 2 Years
Education Type: Full Time
Language of Study: English

Table 3: Master's Program Curriculum

	Course Name	ECTS	Evaluation	Course Type
1.	Introduction to Cryptocurrencies and Blockchain	6	Exam	General
2.	Money and Banking	1	Exam	General
3.	Blockchain Technology and Existing Financial Systems	5	Exam	General
4.	Blockchain and Consensus	6	Exam and Project	Core
5.	Basics of Smart Contracts and Creation of New Tokens	6	Exam and Project	Core
6.	Blockchain and the Law State Channels and Privacy	6	Exam	General
7.	Disruptive Innovation and Exponential Technologies	6	Exam	General
8.	Legally intended Smart Contracts/ Smart Contracts and Security by Design	6	Exam	Special
9.	Practical Lab on Smart Contract and Digital Currency Programming	6	Project	Special
10.	Distributed Systems	3	Exam	Core
11.	Blockchain; Decentralized Political Technology	3	Exam	Special
12.	Blockchain Technology, Cryptocurrencies and Information Systems	3	Exam	Special
13.	Business Process Management and Blockchain	3	Exam and Project	Special
14.	Thesis	30		

The entire curriculum is divided into two semesters. The first semester is consisting of the six courses introduction to cryptocurrencies and blockchain, money and banking, blockchain technology and existing financial systems, blockchain and consensus, basics of smart contracts and creation of new tokens and blockchain and law state channels and privacy. Second semester consisting of seven courses disruptive innovation and exponential technologies, legally intended smart contracts, practical lab on smart contracts and digital currency programming, distributed systems, blockchain; decentralized political technology, blockchain technology, cryptocurrencies, and information systems and business process management and blockchain. Finally, program will be accomplished with master thesis which will summarize all the theoretical and practical knowledge.

FUTURE DIRECTION:

The syllabus of the curriculum proposed for the master level program which includes presentations, study materials, suggested readings and modes of teaching can be made to overcome the limitation in the implementation of this curriculum.

REFERENCES:

1. Kersti Kaljulaid, “Estonia is running its country like a tech company” Quartz.com, Feb 2019. [Accessed on 02/12/2019]. Available https://qz.com/1535549/living-on-the-blockchain-is-a-game-changer-for-estonian-citizens/.
2. Anderson, Lorin W.; Krathwohl, David R., 2001 at http://www.unco.edu/cetl/sir/stating_outcome/documents/Krathwohl.pdf
3. Blossom Summer School, 2019. [Accessed on 02/12/2019]. Available https://www.uni-rostock.de/internationales/rostock-international-house/sommerschulen/blossom/blossom-2019/
4. Beqa, A., “A MOOC for Teaching a MSc-Level Blockchain-Tech Course”, master thesis, Tallinn University of Technology, 2015.

Courses

for teachers and trainers

Introduction to blockchain for cybersecurity IoT and Blockchain

O2: Blockchain Curriculum for Teachers

Introduction to Blockchain for Cybersecurity

LEARNING OBJECTIVES, OUTCOMES, AND TARGET LEARNERS:

This topic is addressed to teachers to improve their knowledge in the field of blockchain technology in general.

This curriculum is based on blockchain technology and its applicability in different disciplines such as financial, commercial, ICT, cryptographic, distributed systems, cyber security, adapted to new innovative business models, etc., for: teaching professionals to learn the theory and practice of one or more disciplines at different educational levels; conduct research; improve or develop concepts, theories and operational methods pertaining to their particular discipline; and prepare scholarly papers and books. Familiarising and understanding of new security technologies in decentralized environment.

Also, creates the premises for developing research projects in which IT security models are used for both detection and protection of organisations information and data.At the same time, this course helps to prepare teachers, students and entrepreneurs to provide an overview of blockchain technology. Also, through this curriculum the human resource will be prepared to develop a solid understanding of the basic structure of blockchain technology for the application of the latest models and technical tools specific to it. All these having the purpose of developing different solutions for the market economy.

EVALUATION:

At the end of the course, a test will be carried out by the participants to obtain the evaluation of the different aspects of the modules delivered in the curriculum, realized on a similar platform forms.google.com, as survey forms.

CONTENT:

1. Blockchain basics

   - blockchain and bitcoin definition, structure and basic operations;
   - algorithm and technique;
   - blockchain protocols;

2. Introduction to Cryptography

   - brief history
   - symmetric-key cryptography
   - asymetric-key encryption;
   - public-key cryptography
   - digital Signatures
   - concept of hashing and SHA family;
   - verifying data.

3. Application of Cryptography to Blockchain

   - using hash functions to chain blocks
   - digital Signatures to sign transactions
   - using hash functions for Proof-of-Work.

4. Blockchain and cybersecurity

   - motivation
   - example of decentralized opensource project

BIBLIOGRAPHY:

- Amoroso E. 1994, *Fundamentals of Computer Security Technology*, Prentice Hall International Editions
- Patriciu, V.V., şi alţii, *Securitatea informatică în UNIX şi Internet*, Editura Tehnică, Bucureşti, 1998
- Diffie W., Hellman M.E., *Multiuser criptography,* National Computer Conference, New Zork, 1976
- D. Hellman, W. Diffie, *Multiuser cryptography*, National Computer Conference New York, 1976
- R.L. Rivest, A. Shamir, L. Adleman, *On digital signatures and public-key functions*, Comm. Os ACM, 1976
- R.L. Rivest, A. Shamir, L. Adleman, *A description of a Single-Chipimplementation of RSA cipher*, LAMBDA Magazine 1, 1980

O2- Blockchain Curriculum for Teachers

IoT & Blockchain

General objective

The course creates competences regarding IoT environment and the IoT security, based on IoT features and risks and the blockchain application as solutions for securities risks. Also, creates the premises for developing research projects in which blockchain models are used for the benefit of IoT systems

. ***Specific objectives***

Familiarising and understanding of new security technologies.

Prerequisites

.- of curriculum: Business Management System; Big Data; Document Security

- of competences: Current use of IT instruments and data security corresponding to the topics studied during undergraduate studies

1. Acquired specific competences

Module1	**Internet of Things** C1.1. What is the Internet of Things? C1.2. How IoT works C1.3. What is an example of an Internet of Things device?
Module 2	**Overview of IoT Features** C2.1. IoT benefits to organizations. What are the benefits of the Internet of Things for consumers? C2.2. IoT tools and technologies. IoT Hardware Providers. IoT Applications C2.3. IoT in Projects. Consumer and enterprise IoT applications. IoT-Enhanced Human Experience. Private sector projects
Module 3	**IoT Security** C3.1. IoT security, risks and vulnerabilities. Threats. Vulnerabilities in IoT Systems Attacks C3.2. Cyber security and the IoT. Making IoT System more Secure. Adequate data C3.3. IoT security incidents
Module 4	**Blockchain & IoT** C4.1. Challenges and opportunities. The problem with the current centralized model. Decentralizing IoT networks. The blockchain approach C4.2. Applications for IoT and Smart Systems C4.3. Challenges C4.4. Blockchain-IoT players and their use cases. Supply Chain Focused. Data Marketplaces. Hardware / Connectivity Focused. Energy Market

2. Contents

8.1. C(C)	
1	IoT
2	How IoT works
3	Examples of IoT
4	IoT benefits to organizations
5	IoT tools and technologies
6	IoT in Projects
7	IoT security, risks and vulnerabilities
8	Cyber security and the IoT
9	IoT security incidents
10	Blockchain & IoT. Challenges and opportunities
11	Decentralizing IoT networks. The blockchain approach
12	Blockchain applications for IoT and Smart Systems
13	Blockchain Challenges in IoT applications
14	Blockchain-IoT players and their use cases
8.2. S(S)	
1	How IoT works.
2	IoT tools and technologies.
3	IoT security, risks and vulnerabilities.
4	Cyber security and the IoT
5	Blockchain applications for IoT and Smart Systems
6	IoT security incidents
7	Blockchain applications

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[1]. Antonopoulos, A.M. (2010). Mastering Bitcoin, O'Reilly Media, Inc., Sebastopol, US.

[2]. Katz, J., Lindell, Y., *Introduction to Modern Cryptography*, Chapman & Hall/CRC, 2008

[3]. Yaga, D., Mell, P., Roby, N., Scarfone, K. (2018). Blockchain Technology Overview, National Institute of Standards and Technology, US.

[4]. Treleaven, P., Brown, R.G., Yang, D. (2017). Blockchain Technology in Finance. Computer 50(9), pp. 14-17.
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[6]. https://rubygarage.org/blog/blockchain-use-cases-in-fintech
[7]. https://www.disruptordaily.com/blockchain-use-cases-crowdfunding/
[8]. https://inc42.com/features/what-are-the-most-interesting-blockchain-applications-in-fintech/
[9]. https://blockgeeks.com/guides/what-is-hashing/
[10]. https://www.coindesk.com/math-behind-bitcoin

Course Name

0.1 Introduction

Welcome to the XXX. This course is dedicated to XXX...

0.2 Important Information

The following resource contains all the essential information your need to know for this course.

Important Information (Page)

Course Overview

This course will XXX

Course content has been organized in five modules, which are:

Module 1: XXX

Module 2: XXX

Module 3: XXX

Module 4: XXX

Module 5: XXX

Module 6: XXX

Course Duration

The course has been setup as self-paced course. This means that participants have the full responsibility of their progress, thus the course is flexible within a wide time frame.

The time you need to complete this course has been estimated to XXX hours, and you have XXX months (XXX days) from your registration to complete the course. This includes reading material and taking the quizzes.

Course Assessment

Each week contains a mandatory reading activity, an additional resource, and a short quiz.

In order to move on to the next Module, you need to complete the reading activity and the short quiz, with a score 90% or higher. These quizzes do not affect your course total, yet you need to succeed on them in order to move on with the course. Unlimited attempts are allowed in the short quizzes, yet there are negative scores applied in wrong answers, so take the time to think before answering.

Upon the successful completion of each module a small badge will be automatically awarded to you.

Having successfully completed all the five modules, you will be allowed to move on to the sixth Module: XXX. In this module you will find the scenario activity that worth 40% of the course total, and the final timed quiz that worth 60%.

To successfully complete the course, you need to reach 80% or higher in the course total.

Certificate and Badge

Having successfully completed the course you will be allowed to download your certificate, as well as the course badge, which depending your score, it may be Bronze, Silver, or Gold!

Enjoy your course!

0.3 Communication within the Course

Although the course is self-paced you may feel the need to communicate with teachers or your peers. That is why the two following forums are offered. The Announcements is only for teachers' announcements, while the Coffee Shop is the forum you may use to reach your peers or teachers.

Announcements Forum (News forum)

Your teachers may use this forum to share general news and announcements regarding the course. Posts created in this forum are also automatically sent to your inbox.

Coffee Shop Forum (Forum)

Feel free to use this forum to reach your peers or teachers. You may use it to share a quick introduction of you, ask a query, or share a XX story!

1.0 – Module Name

1.1 Introduction

In this module you will...XXX

1.2 Learning Outcomes

By the end of this module, students will be able to: *(use Bloom's taxonomy for learning outcomes)*

- Knowledge: cite / define / identify / label/ list / match / name / recall / recognize / reproduce / select / state
- Comprehension: classify / convert / describe / explain / extend / give examples / illustrate / interpret / paraphrase / summarize / translate
- Application: apply / arrange / compute / construct / demonstrate / discover / modify / operate / predict / prepare / produce / relate / show / solve / use
- Analysis: analyze / associate / determine / diagram / differentiate / discriminate / distinguish / estimate / infer / order / outline / point out / separate / subdivide
- Evaluation: appraise / assess / compare / conclude / contrast / criticize / discriminate / evaluate / judge / justify / support / weigh
- Synthesis: combine / compile / compose / construct / create / design / develop / devise / formulate / integrate / modify / organize / plan / propose / rearrange / reorganize / revise / rewrite / tell / write

1.3 Studying Material (Readings)

Click the following link to access the studying material of this module. Reviewing this material is prerequisite to move on.

XXX (SCORM, Lesson, Page, File, Book)

1.4 Activity

The following link represents the short quiz of this module. The quiz consists of five multiple choice questions and you may take it unlimited attempts. You need a score over 90% to move on to the next module.

Remember! Do not rush, negative scores are applied in wrong answers.

XXX (SCORM, Lesson, Quiz, Forum, Assignment)

1.5 Additional Resource

Click the following link to access some useful additional content for this module. Reviewing this content is highly recommended, yet not mandatory

XXX (File, URL, Page)

1.6 Checklist

Before moving onto the next module, open the following link and confirm that you have completed all the requirements for this module!

Checklist (Checklist, Page)

* In the final Module ensure you'll include a course evaluation survey.