



University Blockchain Research Initiative (UBRI):

Boosting blockchain education and research

Yebo Feng^{ID}, Jiahua Xu, and Lauren Weymouth

Since its conceptualization, blockchain technology has witnessed continuous and rapid development, bringing profound changes to computer science, law, and economics. In 2008, the initial blockchain

system was merely a growing list of records linked together using cryptography. Today, however, blockchains have become the foundation of most digital currencies, robust cloud computing platforms, and dependable databases for tracking

supply chain information. Despite challenges and controversies, blockchain technology has the potential to help build a trustworthy and efficient digital world.

However, the emerging blockchain technology has not yet been widely



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incorporated into current education systems, and there are still a lot of problems and challenges to be solved in this domain. To promote the popularization, development, and transformation of blockchain, Ripple founded the University Blockchain Research Initiative (UBRI), a global network of top universities

around the world pursuing public education, academic research, technical development, and innovation in blockchain, cryptocurrency, and related financial technologies (FinTech). Since UBRI's inception in 2018, Ripple has funded more than 40 university partnerships, supporting more than 500 research

projects and new or modified course curricula for more than 280 university courses.

This article shares the education and research experience of UBRI partners over the past four years regarding blockchain technology, aiming to provide empirical support for blockchain- and FinTech-related education, share new research achievements in the UBRI network, and illuminate areas of future research.

Education reform for blockchain

As an emerging technology, blockchain education has not become commonly available at higher education institutions around the world. However, the industry urgently needs a large number of blockchain talents, not only for blockchain-based system development and maintenance but also for helping society leverage blockchain technologies correctly to promote the healthy development of the digital world. Therefore, to fill the talent gap, Ripple has funded UBRI-partnered universities to adopt various methods to promote blockchain-related education.

Curricular education

For universities with adequate blockchain facilities, teachers, students, and budget, it is practicable to recustomize the entire curriculum system to cultivate comprehensive blockchain talents. For example, University College London (UCL), one of the major UBRI partners, has developed several blockchain and FinTech curricula and proposed some master's degree programs based on these. Table 1 demonstrates the module content of the Financial Technology MSc and emerging digital technologies MSc degree programs, two FinTech degrees designed by the UCL Centre for Blockchain Technologies (CBT). From Table 1, we can see that CBT not only expects FinTech students to grasp engineering and technical details of blockchain but also equips them with plentiful cutting-edge financial

TABLE 1. Module content of the Financial Technology and Emerging Digital Technologies Master of Science (MSc) programs created by the UCL Centre for Blockchain Technologies.

MSc PROGRAM	COMPULSORY MODULES	OPTIONAL MODULES
Financial Technology	<ul style="list-style-type: none"> Machine Learning With Applications in Finance Blockchain Technologies Digital Finance Innovation and Strategy in Finance M.Sc. Financial Technology Project 	<ul style="list-style-type: none"> Operational Risk Measurement for Financial Institutions Financial Engineering Database Fundamentals Software Engineering and Product Management in Financial Technology Entrepreneurship: Theory and Practice Data-Driven Modeling of Financial Markets Applied Computational Finance Networks and Systemic Risk Algorithmic Trading Financial Market Modeling and Analysis Advanced Machine Learning in Finance Policy and Regulation for Financial Technology
Emerging Digital Technologies	<ul style="list-style-type: none"> Data Science Blockchain Technologies Digital Technologies and Business Strategy Database Fundamentals M.Sc. Emerging Digital Technologies Project 	<ul style="list-style-type: none"> Entrepreneurship: Theory and Practice Networks and Systemic Risk Algorithmic Trading Computer Security I Introduction to Machine Learning Advanced Machine Learning in Finance Digital Finance Innovation and Strategy in Finance Applied Deep Learning Policy and Regulation for Financial Technology Software Engineering and Product Management in Financial Technology Security and Privacy

knowledge, such as analysis and modeling of financial markets as well as risk management. Such curricula seek to achieve a high integration between the blockchain ideological system and modern finance, thereby laying a solid foundation for students to correctly apply blockchain technologies to financial fields, promoting financial inclusion, enhancing the security of financial markets, improving asset liquidity, etc.

However, not all higher education institutions have the resources to redesign the whole curriculum for blockchain. Some UBRI-affiliated colleges and universities tend to offer a few optional blockchain-related courses for students to choose from, thereby embedding basic blockchain knowledge into the existing education system. A major challenge for blockchain education is that, as a complex systemic architecture design, blockchain technology is at the intersection of multiple computer science subfields. Therefore, blockchain-related courses usually require prerequisites, such as “Introduction to Network,” “Applied Cryptography,” and “Principles of Distributed Systems.”

Nevertheless, blockchain-related courses are very popular among senior students because they can learn the cutting-edge development of FinTech and blockchain system design. For example, Stanford University’s course CS251, “Cryptocurrencies and Blockchain Technologies,” covers decentralized applications, consensus protocols, cryptography, and security used in blockchain systems; the University of Nicosia’s course BLOC 522DL, “Smart Contract Programming,” mainly covers developments of decentralized finance (DeFi) applications based upon smart contracts; and Princeton University’s online course “Bitcoin and Cryptocurrency Technologies” starts by introducing how Bitcoin works and then extends into the financial characteristics of cryptocurrencies.

Even for universities unable to offer blockchain-related courses alone,

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UBRI professors still adopt various methods to enlighten students with blockchain concepts. These methods include but are not limited to the following:

- adding a few blockchain-related lectures to existing courses, such as “Principles of Distributed Systems” and “Introduction to Networks”
- holding blockchain seminars to collectively discuss the latest development in this area
- guiding students to conduct blockchain-related course projects.

Most UBRI-partnered universities (e.g., the University of Waterloo, University of Oregon, and University of Pennsylvania) use these approaches to disseminate and successfully popularize blockchain knowledge.

Extracurricular education

In addition to curricular education that takes place in a classroom, UBRI is also engaged in a myriad of extracurricular activities that promote education in blockchain. Compared to curricular educational programs, these are less formal while more inclusive, with the capability to engage a wider community.

Since 2019, the annual Block-Sprint hackathons, co-organized by UCL and UBRI, have attracted thousands of developers and engineers as well as students and educators from computer science, law, and financial economics to contribute to the distributed ledger ecosystem. Participants are encouraged to provide novel solutions to some of the biggest challenges faced by the blockchain economy, such as liquidity, privacy protection, and payment flow. Winners are not only rewarded financially but also with access to education and network resources, such as training and workshops. Overall, each year, we witness hack-

athon projects becoming increasingly sophisticated, demonstrating the steadily increasing levels of knowledge and expertise of the community members.

Every summer, UBRI supports capstone projects among undergraduate and graduate students from higher education institutions, such as UCL and the University of California, Berkeley. With such a project, students can combine thesis writing with an industry placement. As such, students have the opportunity to work closely with industry experts or even leadership from companies such as Ripple Labs, as shown in Fig. 1, and turn theories into practice. This year, for example, a group of five University of California, Berkeley undergraduate students built an auction mechanism for non-fungible tokens. During the past few years, students have explored an array of other topics, including decentralized identity, arbitrage with decentralized exchanges, on-chain Ponzi schemes and their detection, real asset tokenization, and algorithmic crypto trading, to name a few. The temporary summer placement can be transitioned into a longer-term internship or even a permanent position, provided there is excellent performance during the capstone project period.

Free-access seminars offer another channel for educating a broader audience on blockchain and distributed ledger technologies. Most prominently, the UCL CBT has been hosting monthly seminars open to the public (UCL CBT, 2021). Since the beginning of the pandemic in early 2020, the seminar series has assumed a remote, online format, which achieves an even wider outreach. The seminar series invites speakers from industry, academia, and regulatory bodies, who discuss business opportunities and

pain points, research findings, and legal matters in the blockchain space. Some of the most well-received seminars include “Resource-Event-Agent (REA), Triple-Entry Accounting (TEA) and Blockchain: Converging Paths to Shared Ledger Systems,” “We Must Conceptualize and Measure Separately Decentralization and Distribution,” and “An Inclusive Central Bank Digital Currency (CBDC): Policy and Technology Issues.” In the United States, Morgan State University, the University

of North Carolina at Chapel Hill, and Georgetown University have also been offering free online Fin-Tech webinars.

Besides the aforementioned efforts, UBRI also provides many other learning resources to engage people outside the campus or without any blockchain background. For example, the Webby award-winning podcast *All About Blockchain* (available at <https://podcasts.apple.com/us/podcast/all-about-blockchain/id1525978924>) (Fig. 2) aims to help

the general audience to better understand blockchain by interviewing scholars who are developing real use cases that solve today's challenges. Textbooks and Coursera courses composed by UBRI-partnered professors and instructors make blockchain education accessible and affordable to the public. In addition, UBRI fosters surveys, tutorials, and systematization of knowledge papers, which are of particular interest to newcomers to the blockchain space in both academia and industry. UBRI believes that the best way to help the healthy development and rapid popularization of blockchain technology is to disseminate relevant knowledge to the general public.

Catalyzing blockchain research

Blockchain-related research is another important piece that UBRI aims to catalyze. Besides funding partnered universities so they can reform education systems for blockchain tech, UBRI has invested heavily in helping professors, scholars, and graduate students to conduct blockchain-related research, thereby solving world-class challenges regarding blockchain design, security issues, DeFi, regulation, etc. In addition, UBRI keeps working on creating synergies between different universities as well as between academia and industry through different channels. For example, the annual academic conference UBRI Connect (Figs. 3 and 4) convenes scholars from more than 40 partnered universities to exchange their ideas and show their findings. UBRI also organizes exchanges between industry and academia blockchain experts to let both parties understand each side's challenges and state-of-the-art solutions.

During the previous academic year (2020–2021), UBRI-funded researchers carried out a wide variety of blockchain-related research in different fields, such as computer science, finance, and economics. They generated more than 500 pieces of research output, ranging from open



FIG1 Ripple CTO David Schwartz at the University of Tokyo generating interest in the Internet of Value.



FIG2 *All About Blockchain* podcast recording with an MBA student discussing blockchain use in the energy sector.

source software and applications to journal articles, conference papers, and books. Particularly, there are 166 peer-reviewed academic papers published in well-reputed venues, such as *IEEE Transactions on Dependable and Secure Computing*, *IEEE Symposium on Security and Privacy*, and the IEEE International Conference on Computer Communications.

Figure 5 illustrates the statistics on the number of blockchain-related papers published by UBRI researchers in different fields, which also indicates the hot areas of current blockchain research (e.g., security and privacy as well as finance). By studying promising innovations in blockchain, analyzing past and ongoing research projects, and communicating with researchers in both industry and academia, we have identified six promising frontier research directions related to blockchain, aiming to catalyze further cutting-edge scientific discovery and technological innovation.

Measurement and analysis of blockchain

Since the onset of the mainstream adoption of blockchain-based systems and digital FinTech, the numbers of use cases and end users have both grown dramatically. Blocks continue to expand, and the underlying technology continues to evolve and improve. As early blockchain systems have advanced and broadened, they have become more difficult to track and analyze. Therefore, it is vital for researchers to continue to probe, measure, and analyze current blockchain systems to evaluate the effectiveness of their design, understand the real-world implications of the technology, and inspire future applications, scientific theories, and system designs.

This research direction is also relatively straightforward to conduct due to the transparency and traceability of most blockchain systems. Researchers can fetch extensive historical data from a blockchain system with existing tools, application programming interfaces, or open source resources. Additionally, researchers can utilize a variety of

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data analysis methods to analyze the collected blockchain data, such as traditional statistical approaches, machine learning algorithms, and mathematical modeling.

Continued advances for blockchain infrastructure

Over the past few years, researchers have contributed to significant innovations in blockchain architectures, such as new Byzantine fault tolerance consensus mechanisms, mutable blockchain systems, cross-chain

communication protocols, adaptive blockchain application interfaces, and more. These advances not only make the blockchain system more powerful and efficient but also broaden the range of possible use cases, opening up new possibilities.

However, there is still much room for improvement in current blockchain design. For example, existing privacy-preserving blockchain schemes are still not efficient enough to operate at scale; it is difficult for current consensus mechanisms to



FIG3 Stanford's Darrell Duffie with Ripple's James Wallis discussing CBDCs at the annual UBRI Connect conference.



FIG4 Georgetown University and UCL partnered on the Institutional Digital Asset Adoption panel and book in UBRI Connect.

Blockchain also shows promise as a tool for making financial systems and services more inclusive, affordable, and participatory—a growing focus for university researchers globally.

simultaneously achieve good decentralization and scalability; most miner-assisted blockchain systems suffer from miner extractable values (MEVs). Therefore, it is of great significance and necessity to continuously research and improve the fundamental algorithms and design of blockchain.

Security of blockchain

Security is the foundation of blockchain technology. However, current blockchain systems are still vulnerable to a variety of attacks and malicious inputs. For example, most blockchain systems can be easily overwhelmed by blockchain denial-of-service attacks; miners can leverage MEVs to disturb the normal operation of blockchains or attack the upper-layer applications based on them; the communication mechanisms between nodes may suffer from traditional cyberattacks (e.g., a routing attack, middle-man attack, etc.).

To preserve and strengthen this foundation, researchers need to keep exploring possible threat models of blockchain, proposing advanced

cryptography and encryption algorithms as well as modifying or developing entirely new comprehensive analysis methodologies. With several years of research, most UBRI-supported researchers believe that blockchains and FinTech can become more secure and dependable over time—in part, in anticipation of more powerful computing and security threats from bad actors—and they will continue to work toward supporting this outcome.

Blockchain-based applications for social good

The dependable, traceable, immutable, and decentralized features of blockchain-based systems make this technology applicable to more than just the financial and Internet sectors. Recent developments in this space have shed light on its potential to optimize how civil society functions, improving a wide range of applications, including medical systems, welfare systems, electrical grids, supply chains, and other socially impactful use cases. Blockchain also shows promise as a tool

for making financial systems and services more inclusive, affordable, and participatory—a growing focus for university researchers globally. In the future, researchers in different fields should deepen cooperation with each other and continue this multidisciplinary road map, developing more blockchain-based applications to benefit society in a decentralized manner.

Reshaping the financial system in the blockchain era

New blockchain-based FinTech will bring potentially transformative changes to the current global financial system. Central banks are experimenting with digital currencies (CBDCs) as a complement to traditional fiat currencies due to their secure, efficient structure. Central banks are also exploring the potential for CBDCs to make their national and regional economies more efficient, inclusive, and equitable. A wave of new financial derivatives continues to be brought to market, DeFi protocols have been proposed to better manage digital assets, and a new generation of trading platforms has brought users fairer and more effective bidding mechanisms. It is, therefore, vital for researchers to catalyze the financial reshaping healthily and smoothly by proposing new blockchain-based FinTech, pointing out

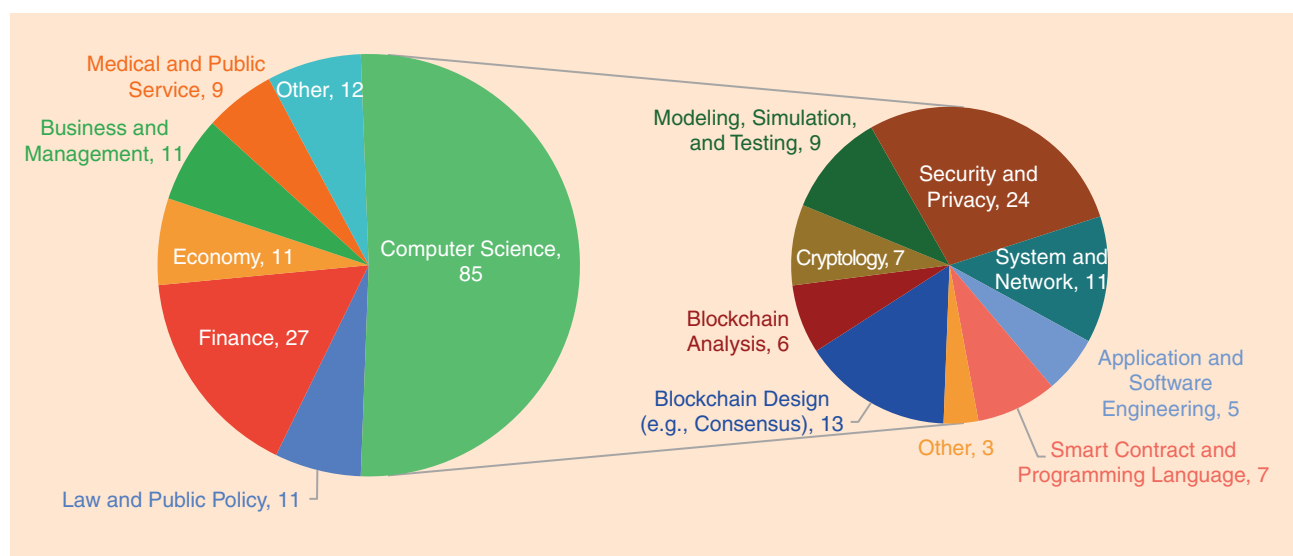


FIG5 Statistics on the number of blockchain-related papers published by UBRI researchers in different fields from 2020 to 2021.

their loopholes and deficiencies, and analyzing the positive and negative impacts of this transition.

Policy and regulation for FinTech

The majority of researchers agree that clearer and more comprehensive regulation in FinTech is essential to ensuring these technologies serve society's best interests and enable, not stifle, competition and innovation. Suitable regulation should support a fully functioning and interoperable global economy, provide effective protection of consumers and collective public rights, enable the continued adoption of FinTech, and support the future development of blockchain technology. However, in many countries, laws and regulations that apply to traditional financial markets have been slow to adapt to FinTech like blockchain and cryptocurrency. Therefore, researchers in the fields of law and social science should play an important role in defining future financial supervisory and regulatory models that can help inform appropriate policies and regulations.

Conclusion

With the gradual development and application of blockchain technology in various fields, higher education institutions should make appropriate changes in scientific research and education to adapt to this trend. This article introduces changes and efforts made by UBRI-partnered universities regarding blockchain education and research, aiming to provide experience for the widespread dissemination of blockchain knowledge and suggest promising research directions for blockchain researchers. We believe that through the proper development and use of blockchain technology, society as a whole will become more convenient, dependable, and trustworthy.

Read more about it

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About the authors

Yebo Feng (yebf@uoregon.edu) is a Ph.D. candidate in the Department of Computer and Information Science at the University of Oregon, Eugene, Oregon 97403 USA. He is also a research assistant at the Center for Cyber Security and Privacy. His research interests include blockchain security, network security, and system security.

Jiahua Xu (jiahua.xu@ucl.ac.uk) is a lecturer in Financial Computing at University College London, London WC1E 6BT U.K., where she teaches "Blockchain Technologies" and "Digital Finance." She is an award-winning researcher at the university's Centre for Blockchain Technologies and serves as the program director of the Emerging Digital Technologies MSc degree under the Computer Science Department.

Lauren Weymouth (lweymouth@ripple.com) is a director at Ripple, San Francisco, CA 94104 USA, where she leads its University Blockchain Research Initiative, a partnerships program that funds financial technology curriculum development, research, technical projects, entrepreneurship, and student activities. She also hosts the Webby award-winning podcast *All About Blockchain*, interviewing scholars who are developing real use cases that solve today's challenges.

