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A Curriculum for the Body of Knowledge in Open Finance

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Abstract

This paper addresses an identified skills gap in graduates who are entering the Open Finance workplace. The latter is a new sub sector of finance centered on the use of third-party permissioned data. We address the concern that such graduates lack commercial awareness and relevant financial work experience. We build on the Curricular Domains Model. This expresses the curriculum as knowledge, action and self-domain. We first identify the needs of employers through an embedded researcher approach in collaboration with the Smart Data Foundry. We then apply an Integrated Curriculum Design Framework (ICDF) to the findings in order to develop a transdisciplinary curriculum that can be applied to a master's degree program. Our contribution is in facilitating a systemic combination of the finance and computing disciplines to create a new one that addresses this field. We believe our proposed educational offering can assist with the challenges that are presented by the adoption of Open Finance.

Keywords: *Fintech; Open finance*

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1. Introduction

In this paper we explore the new and growing field of "Open Finance" and the implications for an educational curriculum to support those seeking an academic qualification. This goal is promoted by the Higher Education Funding Council for England (HEFCE). It recommends that transferable skills are developed in order to enhance the employment prospects of students. We identify what these are, and we make recommendations for the syllabus that would support a taught degree in Open Finance at Masters level. We do this using a transdisciplinary approach, whereby the holistic fusion of finance and technology expertise and practice results in a body of new knowledge and skills to deliver employable graduates in this original field. Our approach transcends these two very different disciplines by the integration and application of domain level understanding and transdisciplinary-inducing pedagogies.

The resulting curriculum is not simply the addition of the parts. It delivers a type xenogenesis that we argue is appropriate for this new financial specialization. Open Finance is a broad term that describes the extension of "Open Banking" that grants third-party service providers, such as pensions, investments and savings institutions access to consumer historical data held (Brodsky and Oakes (2017). It is based on data-sharing principles that enable third-party providers to access customer data. The Financial Conduct Authority (FCA) observes that there is "a degree of consensus" on certain aspects of Open Finance. This includes the legislative framework, the regulatory backdrop, the common standards and the implementation protocols (FCA (2018). As such, there is a sufficient body of knowledge to make a Masters degree level taught program that could fulfill the Durkheim, Halbwachs, and Dubet (1938) criteria. Namely, a curriculum that possesses an educational structure that enables post graduate students to achieve learning outcomes in this specialist area. We believe our proposal will prove useful for the ongoing development of Open Finance as an important initiative in the financial sector by supplying it with graduates fit for purpose.

Open Banking was first introduced in the United Kingdom in 2018, following the implementation of the EU Directive on Payment Services (PSD2) and the formation of the Open Banking Working Group (OBWG). Insights into the relevance of this legislation for financial technology can be found in Romanova et al. (2018). The legislation itself was prompted by a review of the retail banking market. This highlighted the banking sectors monopoly on client data. It suggests poor access to data is the biggest impediment to dissatisfied customers switching accounts. The individuals surveyed found the process of switching banks difficult. In addressing this, PSD2 permitted permissioned third-party data. The idea behind this was to give other institutions access to banking data and therefore make it easier to change accounts. The innovative use of this third-party data was an unforeseen, but extremely beneficial, consequence. As observed, Open Finance evolved from Open Banking (Rousseau (2019)). The term therefore describes a set of protocols that grant third-party access to data as generated by

financial institutions, rather than just retail banks. There has been a dramatic increase in such data as a result of what is termed "high volume", "high velocity", and "high variety" information (Hussain and Prieto (2016)). The way such data is obtained, analyzed and used is also evolving. This in turn has led to a wave of innovation in the uses of that data for the provision of financial services, all of which need to be incorporated into the proposed curriculum. A whole new sub sector has been created, comprising Account Information Service Providers (AISP's) and Payment Initiation Service Providers (PISP's). In the United Kingdom, an authorized AISP can ask for permission to connect to a bank (or financial company's) account and access the data. Similarly, a PISP can ask for permission to connect to a bank (or financial company's) account and initiate payments on the customer's behalf.

Open Banking has subsequently been extended to a number of jurisdictions and the term Open Finance has been adopted to describe the widening of this initiative to other financial sectors such as insurance, pensions and asset management. The initiative has the power to enrich consumer experience of financial services when combined with new data applications (Zachariadis and Ozcan (2017)). It can be used to leverage the value of data through the use of consent, allowing for it to be shared and enabling wider access to financial advice, products and services. Third-party providers can use the data to customize and tailor financial offerings, like credit assessment, automated savings and investment, money management, and other Banking as a Service (BaaS) offerings.

Open Finance has been flagged as of significant interest to the FCA. Its Director of Competition observes that this nascent sub sector requires coordination and consistency (Mills, S. 2019). We suggest this supports the need to define a coherent program of learning for students looking to enter the sector. This should include a broad finance based perspective, an analytical component, systems and IT skills, including programming ability. As a Masters program, it should also include leadership, the exercise of initiative in complex and unpredictable professional environments which we suggest should be gained through a work-integrated learning curriculum component. We believe the fusion between these disciplines with crafted learning objectives, contemporary learning activities, and applied assessment will positively impacts learning outcomes and supply work ready graduates for the forecasted professional demand (Biggs (2003), Biggs and Tang (2011), Bartholomew and Curran (2017)).

In identifying the skills and attributes required, we engaged with the Smart Data Foundry (formerly the Global Open Finance Centre of Excellence). This specialist research institute is hosted by the University of Edinburgh. It is funded via the UKRI Strength in Places initiative and established with a mission "open finance for good". Our work is timely. Incumbents are looking for accredited personnel to help them bridge into new world opportunities and react to disruption. Start-up fintechs, also part of the Open Finance landscape, are looking to accelerate credibility. Employers have observed that there exists a skills gap in addressing the need to embrace Open Finance (Karkkainen et al. (2017)). According to WEF The Future of Jobs Report

2020, a global study covering 291 global companies, collectively representing more than 7.7 million employees worldwide, new technologies will increase demand for new jobs as skills set. 59% of the Financial Services Companies surveyed cited skills gaps in the local labour market as a barrier to adopting new technologies (Archer and Davison (2008)). According to The International Employer Barometer, an independent study covering employers that represent over 750,000 workers, IT skills are in high demand (Archer and Davison (2008)). The report observes that there remains a lack of commercial awareness and relevant financial work experience amongst the majority of IT professionals which we believe our proposal addresses. The curriculum we propose also fills a gap in educational provision.

The "Body of Knowledge" was scoped out as explained in Section 2, and is defined in Section 3. The resulting program outcomes are listed in Section 3 in bullets A1-A10. The syllabus is covered in Section 4. Figure 1 depicts the curriculum model and Figure 2 summarizes the recommended programme structure in detail.

2. Methods and identification of Educational outcomes

We approach the task of identifying a body of knowledge for Open Finance through an Integrated Curriculum Design Framework (ICDF) (Murphy and Curran (2018, 2019)). The ICDF consists of a three-phased approach to program design, the process is illustrated in Figure 1. At the core of ICDF is a shared understanding of the curriculum purpose and constructs. It begins with industry-facing research and analysis. We undertook this stage in collaboration with Smart Data Foundry. The next stages are program and module design and then program alignment. At the core of ICDF is the Barnett and Coate (2005) curricular domain model, a blueprint that focuses curricular designs on; what the students need to know (Knowledge Domain), do (Skills Domain) and, be (Attributes domain).

In the first stage of the ICDF, we used an embedded researcher method. This involved the lead author undertaking a part-time three-month secondment within Smart Data Foundry. This resulted in insights through regular meetings, interviews and discourse. The collaboration proved helpful to the curriculum design as Smart Data Foundry has several data-driven research projects focused on market-facing user challenges. These include the Global Economic Observatory, the Innovation Environment, Global Open Finance Technical Standards, Customer Data Protection Research Unit and Economic Crime. They inspired composite elements of the program structure. Our Smart Data Foundry engagement combined with desk-based research suggested the curriculum should focus on the broader definition of employability and incorporate both "soft skills" and "hard skills" (Ritter et al. (2018)). Specific emphasis was placed upon, social and emotional skills including building identity, self-efficacy, reflective practice and resilience. In discussing the proposed curriculum, Smart Data Foundry employees suggested it is important to recognize psychology and behavioral economics and how data

science plays an important role in the integration of the disciplines. They favor an outcome-based approach that took into account a wide range of potential employers, going beyond finance.

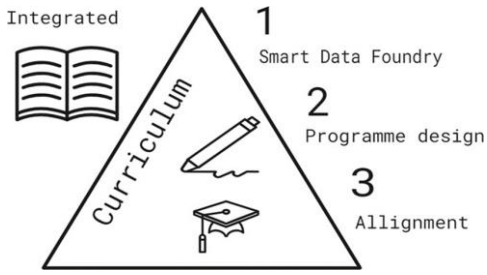

Figure 1. The diagram illustrates our approach to the creation of Open Finance program content and learning outcomes. We engaged with the Smart Data Foundry (previously the Global Open Finance Centre of Excellence GOFCoE as depicted in the figure) in order to research industry needs from a Masters level educational offering.

During the research and analysis stage with Smart Data Foundry, we found that the cognitive skills that are required to support the data centered nature of Open Finance should include a knowledge and understanding of various financial applications and uses of financial data. Meta cognitive skills such as analytical thinking and learning to learn. The practical skills, meanwhile, should focus on being able to communicate the relevance and importance of Open Finance. Finally, collaborative skills should be included in the mix, core to the business school approach (McKenna, Cotton, and Van Auken (1995)). We found that the industry believes, being able to problem solve in a team environment is an important ingredient to foster financial sector innovation. The increased complexity introduced by the permissioned access to data means that communication, leadership, and problem solving are important graduate skills. We suggest this should comprise the specially adapted modules from the field of finance as well as relevant case studies in the programming modules. For example, the pricing of futures and options, typically taught on finance programs, is not necessary. The nature of banking and banking risk is, however, required.

Extending this line of thought, Acemoglu and Autor (2011) argue that there is a difference between skills and tasks. As a result of technology, the later are more important from a pedagogical perspective and this shaped our approach to phase 2 of the ICDF. We propose the assessment strategy of this transdisciplinary program incorporates an applied assessment approach. This element enables graduates to perform workplace tasks. Most importantly, it gives them the skills and understanding to do these efficiently and with added value. We therefore suggest including commercial skills to include the identification of business opportunities. More specifically, Smart Data Foundry recommend a specific focus on:

- Open Finance ecosystem: understanding and having the ability to evaluate and create scenarios of how Open Finance environment might develop. Using the history, technical knowledge and lessons from Open Banking, plus a review of different Open Banking models across the world to enable the student to anticipate some of the market, competition and regulatory forces that might emerge. Open Finance business models: understanding future applications of Open Finance data, and how to think about building strategies to address the phenomena.
- Financial services markets: understanding the basic Profit and loss statement and balance sheet of a bank, a lender, an insurer, and an asset manager. The distinction between retail financial services, wealth and between small and medium enterprises and corporate banking.
- Financial planning markets: understanding the way intermediaries use data and give advice.
- Risk analytics: understanding and having the ability to apply the mathematics behind risk analysis in FS, so the student knows how to build models of credit, insurance, investment and interest-rate risk. Applying these to underwriting risk in these different domains.
- Customer analytics: understanding and the ability to apply statistical analysis to build behavioral models, segmentations, customer valuation models. How to meld quantitative and qualitative customer research to understand how customers are behaving in your sector and with your products.

Moving to phase 3 of the ICDF we address alignment by tailoring content directly for Open Finance as a nascent sector. In this respect, developing a curriculum for Open Finance requires a transdisciplinary approach, typically across different faculties. We highlight that this is different from an interdisciplinary approach, as co-creation of content is required for a full infusion of disciples dependencies. Data science is usually taught by a computer science faculty. Finance, however, is typically taught in business schools. The latter is a topic that requires the incorporation of the practical aspects of the way financial data-sets are structured. We therefore propose a blend of course content, learning outcomes, assessment, and work integrated learning such as industry problems, projects and placements. We believe our proposal is practical in nature. Fichman, Dos Santos, and Zheng (2014) suggest that it is important for business school students to understand technological change and innovation and our holistic approach ensures this is the case.

In seeking an transdisciplinary higher-education outcome, we do imply the adoption of research-based teaching as advocated by Healey (2005) and facilitated by enquiry-based pedagogies. This follows the now standard approach to developing an academic program in a

new field, namely initiating the process by reference to related and existing academic discipline. We try, however, to make it as all-encompassing as possible in line with the Barnett (2009) concept of nurturing and developing the whole person. As Open Finance is a nascent and developing area, we wish to avoid an instructional methodology. Data standards and IT are ever changing. Instead, we seek to incorporate our reflection on the nature of Open Finance and the way financial and data lecturers should leave open space for investigation, creative problem-solving, research and the acquisition of new knowledge cognizant of the required learning outcomes (Null (2016)).

3 The resultant program outline

The resulting transdisciplinary program outline follows Barnett and Coate (2005) Curricular Domains Model. The schema expresses the curriculum as knowledge, action and self-domain. The goal of the program should be for students to demonstrate an ability to critically evaluate and apply the relevant theories and techniques of both data science and finance. Specifically, students should be competent and confident in a financial work environment having acquired a knowledge and understanding of:

A1 Computing techniques and programming skills relevant to Open Finance (Doing).

A2 Specialist knowledge on application programming interfaces (Knowing).

A3 The use of data, both quantitative and qualitative, relevant to the study of finance including generalized linear models and the concepts of time series and cross-sectional data (Doing/Knowing).

A4 The quantitative and statistical tools used in data analysis (Doing).

A5 the fundamentals and principles of taught finance (Knowing).

A6 Presentation and a range of approaches for representing trends and seasonality (Knowing/Doing).

A7 Economic theory and financial institutions, markets and governing bodies (Knowing).

A8 The appropriate use of different types of data structures (Knowing).

A9 A systematic and in depth knowledge of key aspects of data protection law (Knowing).

A 10 The role of privacy and its relationship to individuals, the state and financial I nstitutions (Knowing).

On completion of the curriculum, the qualifying student will be able to code in Python & R and develop API's relevant to data retrieval (action). The student will be able to evaluate and select relevant financial data for analysis (action). The student will be able to select a statistical method

to analyze that data (knowing/action). The student will be able to discuss and present the results in a way that can be understood by financial professionals (action/being). The student will also be able to use financial models and contextualize work within the regulatory framework (being).

Drummond, Nixon, and Wiltshire (1998) point to the difficulties in operationalizing good practice into learning outcomes such as these. One solution is a greater incorporation of qualitative rather than quantitative teaching. Another is to incorporate skills evaluation as an iterative process. Russo et al. (2021) suggest it is writing skills that are desired by employers of accounting and finance graduates. In this way Barnett and Coate's domains can be collectively captured in a final cap-stone project linked to an industry placement project.

We consider the overlap of the knowledge and action domain to be an important differentiator in the curriculum. As mentioned this means the program should teach the student transferable skills. He/she will then have the ability to apply key concepts in an Open Finance work context. Transferable skills such as these have been placed on the higher education agenda to ensure a flexible and adaptable workforce (Kemp and Seagraves (1995)). They are what make graduates immediately employable, in the context of Open Finance, this includes an understanding and proficiency in application programming interfaces, technical standards and data privacy. We further recommended that practitioner guest speakers be an important part of the supported lecture load. This will help address the high levels of redundancy in the technology.

Another key aspect of the knowledge and action overlap is the application of technical standards is essential for interoperability and the success of Open Finance. As banks have multiple data-sets, data has to be gathered prior to any analysis. One way to do this is using Structured Query Language (SQL). The data also has to be cleansed. Adding SQL to the curriculum allows the students to modify database tables and construct index structures from first principles. It also provides a knowledge of the basics of information retrieval.

4 The program structure

In this section, we present a proposed program structure to address the desired program outcomes. We build on the adaptation of Barnett and Coates' (2005) curriculum domains and align the curriculum content from the Quality Assurance Agency benchmark statements on Computing (2019) and Finance (2019) with suggested content on (1) subject knowledge and understanding, (2) subject-specific skills, (3) transferable) skills core modules. We were also cognizant of the nature of Open Finance which merits associated work experience as a fourth category. In that respect, the design and development of software solutions is central to IT skills.

The proposed program structure is presented in Figure 2 as a 180 credit postgraduate module, aligned to the QAA UK National Qualification (2014) and Credit framework (2021). The design was made cognizant of the fact that a curriculum is an educational offering based on a clear

purpose, content and learning experience. It requires some means for assessing whether or not the goal has been achieved. We therefore propose a procedure, process and task-based syllabus based on a combination of core and specialist modules, culminating with a capstone project-based assessment providing an opportunity to practice and mastery skills the skills and practices of an Open Finance graduate.

Our proposal is fundamentally different to existing financial technology courses. This is due to the proposed focus on practical data handling. We further propose a long and thin module in management and strategy. Henze et al. (2020) suggest that this element should include compliance, regulatory, organizations and contractual data handling elements. We see this module as sewing together the diverse nature of the other modules in finance, programming and data.

A thorough knowledge of data privacy is essential. In the financial sector sensitive data is often stored. This includes personal information which the banks and insurance companies use to add value by processing that data and providing services on the back of it. Further when that information is combined move external data sets there is the potential full inferring deep insights into the uses behavior. There are a number of life cycles related to big data privacy these include the data generation phase, storage stage and the processing stage. Encryption based techniques are used in respect of identity and the internal storage path. In the data processing phase anonymization techniques are often used.

The Quality Assurance Agency (QAA) has provided guidance that in addition to the aforementioned mapping, courses should provide an in-depth coverage of the topic so that students can apply what they learn. We therefore propose the modules with a view to students gaining an understanding of just of the subject area but also use cases. In this way, students will be able to apply the learnt principles in their future career. The use cases would also encourage critical and strategic thinking.

The design and characteristics of an Open Finance curriculum should be based on competencies that deliver program outcomes based on formal assessment. These teaching and learning outcomes are typically achieved by lectures supported by seminars, workshops and programming classes. The choice of course materials should reflect the vocational and changing nature of the subject. The module leaders should source materials outside of standard programs and place a greater reliance on self-directed study. The program outcomes, detailed next, should clearly express the MSc, level 7 standard intended and articulated to include the specific practical application of the conjoined subject areas (Ellis (1993, SEEC, 2021)).

As Table 1 demonstrates, the core module should consist of two programming modules. We suggest one of these be an introduction to both Python & R and the other be an introduction to Machine Learning and Artificial Intelligence. The specialist elements should include a number of IT modules. We address these in more detail next. It should consist of four specialist ones,

some of which should be optional choices. Finally, a capstone which would include the aforementioned placement and industry project.

Table 1. Curriculum Model applies to a 180 credit one year Master's degree program. The course includes compulsory elements such as programming, finance and an Application Programming Interface module. The third-party work based project is intended to be done in tandem with an internship placement and addresses a real world corporate data issue.

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Sem	**Progressive Skills Development**	**Level 7 Exit Points**	**Module Titles and Credits**			
S1	Develop	Certificate	X 20 Principles of Finance	X 20 Introductory programming and Database Structure	X 10 Open finance in practice	*X10* *Contemporary Challenges – Regulatory Societal and Industry*
S2	Practice	Diploma	X20 Phyton and R	X 20 API Development	X10 Open Finance Management and Strategy Challenges	X 10 Fundamental of banking
S3	Master	Masters	X60 Third Party data Work-based Project			
	Skills Development		Exploring Statistics and predictive analytics	Quantitative Research Methods		Reflective Account of WB practice

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4.1 Core Finance Modules

The core element in Figure 2 is a principles of finance module. Although the term Open Finance suggests that a taught curriculum on the subject should include the full breadth of finance theory, in practice this is not necessary. We suggest a selective approach to the modules. We do not, however, believe that a new module needs to be designed. What Open Finance and traditional finance share are the variables and identifiers. Selective choice of existing modules is therefore sufficient. General finance knowledge is required. The finer detail of pricing models, ratios and markets is not strictly necessary. That said, the differentiator between a data scientist and an domain expert in Open Finance is an understanding of the context of the data.

The micro-structure of the firm is relevant. There have been a proliferation of new business models as a result of the roll out of Open Finance (Ramdani, Rothwell, and Boukrami (2020). This suggests the existing curriculum in finance also has to adapt. Similarly, as identified by Aeschleman and Gedig (1985), a whole host of new regulatory challenges have arisen. This revision needs to incorporate these.

Scholarly research into the finance curriculum focuses on program structure and design McWilliams and Pantalone (1994). There is a consensus that taught finance has to keep up with industry change and new developments (DeMong, Pettit, and Campsey (1979)). Taught finance typically includes both theory and practice. The modules on the latter should be tailor made to reflect the Open Finance regulatory and entrepreneurial landscape and can be included in the long and thin management and strategy module.

The finance element is to shape the mind of the student. Carrithers, Ling, and Bean (2008) suggest that critical thinking is an important element of taught finance. This is because finance problems are complex and to solve them requires analytical input. This is compounded in Open Finance with the technological element. We therefore consider this an important component.

4.2 Core Programming Modules

The core element in Figure 2 also specifies a minimum of two programming modules. We view this as mandatory as allied to an understanding of IT is the ability to program. As a pre-requisite, a student should be able to understand the basic terminology used in all computer programs. They will need to be able to write, compile and debug programs. Within the field of Open Finance, the ability to program basic SQL from Java and Python is essential. One of the introductory modules should therefore provide a short, intensive, hands-on introduction to the software and tools necessary. The second semester should extend this to include the skills that are required for online information using standard APIs or tools.

The programming element should make students familiar with common tools, repositories, virtual machines and servers. To be useful to industry, they should be able to develop well-structured programs but also be shown how to pick up new skills independently. This requires basic user interaction, file navigation, and system monitoring. The domain of content knowledge should include a block-based programming environment. This should be supplemented by learning analytics, a tool that has proved especially useful in big data pedagogy (Duval (2011)).

4.3 Core Capstone Project and Work Experience

Key to transferable skills is work experience and we propose incorporating this into the 60 credit capstone project. This is a multifaceted assignment that serves as a culminating curriculum experience. We suggest this because employers prefer graduates with work experience. That

said, the nature of the work experience is relevant for example with Open Finance. The student should be able to identify relevant statistical methods that are applicable to their future employers' data-sets. Students should also be able to integrate the knowledge and skills that they have learned in their degree program and be able to fit models, check those models and compare them. This involves an understanding of validity of the assumptions that academics make.

The interpretation of results, and the drawing of a conclusion from those results, is important in an Open Finance work environment. As such, incorporating such experiential learning into the curriculum will result in more employable graduates. That will differentiate the graduates from data scientist and financial professionals. The Frontier Economics "access to data" report identifies five barriers to effective data sharing. There are (1) lack of incentives, (2) lack of knowledge, (3) ethical worries, (4) regulatory and legal risks, as well as (5) cost. An educational curriculum can held address the knowledge deficit. The same report also highlights the societal benefit of open data, the former being something which higher education is focused on promoting.

Obviously the limitations of a work placement need to be made quite clear. Most of the analysis is directed. That said, the students benefit from the practice and enhanced capabilities of practical skills and professional attributes in a professional context. The including project management, personal responsibility and leadership and the communication of advanced concepts and findings.

4.4 Specialist Information Technology Modules

According to Smart Data Foundry, Data-driven Analytics/Analytics for financial services lies at the heart of the skills gap that needs to be addressed and, also lies at the heart of most successful Open Finance strategies. The content, however, should make a distinction between analytics in Open Finance and analytics in Financial Services more broadly. The specialist element in Figure 2 includes three modules that incorporate this based on Information Technology (IT). These should provide a focus on data, computer architectures, database structure, programming languages, operating systems, and artificial intelligence.

We undertook a similar review process on the required technology programs and identify the following adapted modules from the field of computing and data science. There are two instructional methods that can be adopted, lecture and case studies. Pridmore, Bradley, and Mehta (2010) argue in favour of adopting a combination of the two. They also suggest case studies can result in improvements in IT directed learning. In an Open Finance work environment, the ability to configure and administer database servers is also important. This allows the Open Finance professional to conduct data analytics. A core module on the IT side should therefore be Big Data Analytics. This should be designed to introduce students to the

basic aspects of high dimensional data. This should include classical methods for cluster analysis and a range of methods for classification purposes.

We also observe that the collection of domain specific information is central to many business functions in the financial sector. It enhances customer interaction and helps marketing. It also help with fraud detection and cyber security. In this respect deep learning and big data analytics are part of the Open Finance curriculum with the large volume of data available semantic indexing information retrieval and data tagging are also key skills.

Open Finance is embracing Artificial Intelligence and Machine Learning. The data input and generalization of the learned patterns lead to better financial outcomes, such as reduced defaults or better credit assessment. Deep learning algorithms are used in the financial sector to understand complex data representations and achieve higher levels of abstraction. Students therefore need these skills and be able to represent them in ways that defined are useful.

An understanding of the reliability of the IT systems is also required. This includes such concepts as fault-tolerance, security, and access (Kambatla et al. (2014)). Financial companies have a low to zero appetite for failure, so incorporating it in the curriculum makes sense.

Not only is an understanding of how databases work on servers required but also how they work over the Internet. Datasets are increasingly distributed over the Internet, and this requires an understanding of distributed techniques. In such architecture, the data is stored on different platforms and the databases must communicate with one another. The student of such systems should know how to design buffers between the applications and the network in order for the distributed data to remain resilient.

4.5 Specialist Application Programming Interface

The specialist element in Table 1 includes a module on the main tool in Open Finance, an application programming interface (API). Mechtley (2020) argue that the way API's are taught can have broader learning outcomes. Ko, Myers, and Aung (2004). API's can be used to import data into a data-warehouse for further analysis. The incorporation of API's into the curriculum helps establish a framework from which standards and protocols can be taught, thereby strengthening the nature of the subject.

API's have many functions. They can be used to incorporate functionality to existing financial solutions. The modules should focus on the Investing and Saving Alliance (TISA) standards. This is a United Kingdom initiative that has developed a set of API standards for Open Finance. In addition, the Open Savings, Investments and Pensions (OSIP) initiative is an evolving project that should be included. In terms of curriculum, the rapidly evolving standards introduces an element of redundancy into the curriculum. As such, it is advised to make use of frequent industry guest speakers to cover this eventuality.

4.6 Optional modules

The optional element in Table 1 is to provide tailored outcomes for the student. As the suggested program is focused on a specific field, the majority of modules in an Open Finance post graduate offering should be core (Cox and King (2006)). This will provide a structured and common approach across institutions. That said, it is accepted practice to complement these core modules with some optional ones. This gives students the opportunity to take the subjects that are of specific interest. This also allows the student to tailor their post-graduation employment goals with their learning schedule.

The usage of data needs to be incorporated. In this respect, visualization is important (Van Wijk (2005)). The theories of data abstraction and visual perception, as well as other current research, should therefore be included in the program modules. This part of the curriculum can be leveraged by the use of practical assignments. The latter should include the purpose and range or visualization techniques the student should be able to identify different data types and explain how these theories relate to the task at hand.

Optional modules could include (1) digital transformation including adoption and trust; (2) Green Fintech and sustainability; (3) modern banking and financial institutions: management practice. The latter would be useful as Matt, Hess, and Benlian (2015) argue that companies need management practices to handle the complex transformations that these areas are witnessing.

Access to third-party data it enables a whole host of customer solutions and business models. Students should be aware of these issues. Most references in the media to Open Finance are positive in nature, which isn't always the day to day corporate reality.

5 Recommended assessment

Assessment for the proposed program should be an integrative assessment approach to reflect the practical and theoretical blend of the learning outcomes. We do not believe the content is well suited to examination. We note that there is a trend to move to 100 percent course work to capture greater relevance and authenticity through the application of live cases and problems, real data and simulations. We would endorse this approach which correlates to the sector's movement from an traditional assessment of learning approach to one were assessment is utilise as an opportunity 'for' learning and 'as' learning (O'Neill, McEvoy, and Maguire (2020)). In this respect, the assessment strategy should facilitate the development of all three domains of the curriculum, including, skills, attributes as well as knowledge creation. Applied authentic assessments focusing on real world problem solving will facilitate the skills and attribute domains of the curriculum. This should develop graduates able to:

B1 Acquire skills to create, analyze and implement technical solutions for third-party data access and management (Doing).

B2 Analyze, evaluate and interpret data and be able to produce practical reports based on financial data-sets (Doing/Knowing).

B3 Apply skills of mathematical, data and statistical analysis to gain insights into financial services (Doing/Knowing).

B4 Apply the skills taught in order to pursue a successful career path in Open Finance (Doing/being).

B5 Explain findings of any data investigation, both orally and in written format (Doing).

B6 Identify, define and explore financial data and its uses (Doing).

B7 Attain core leadership skills for the finance sector, including effective communication, consulting skills. This includes how to manage disruptive innovation (understand) (Being).

B8 Understand the wider context of digital transformation and innovation (Knowing).

B9 Deploy a high level of analysis and critical judgement in relation to finance theory and data methods (Knowing/Doing).

B10 Identify tacit assumptions behind data analysis and the limitations of data and information (Knowing).

With these program outcomes, graduates should be able to demonstrate a solid conceptual understanding of Open Finance and the nature of the data tools and techniques required to pursue a career in the nascent industry. The authors hope the taught element also introduce an understanding of the ethical use of data, as relates to society and individuals.

6 Discussion

The most important finding from our engagement with Smart Data Foundry was the need for a practically focused industry-aligned curriculum. As such, we present a demand led proposition based on the components of Open Finance and the skills needed by the finance industry. This, combined with need to include both finance and IT disciplines in the offering, leads us to a transdisciplinary approach. An interdisciplinary approach is possible, but we found that teaching modules without context would make the graduates less employable.

Our approach raises the question of whether the proposed curriculum is better for the Open Finance industry than a mono-disciplinary offering such as data science. We believe our

transdisciplinary proposal gives financial institutions more flexibility in being able to think laterally on how to solve analytical problems by using their data. This is because the finance component provides insights that pure data scientists do not generally have.

We observe that Open Banking, as a subject, is already being taught as a degree course. As a result, Smart Data Foundry suggest that Open Finance needs to encompass all of the history, business strategy, regulatory insights, learning about adoption, data privacy and security risks, and fraud issues that are part of an understanding of Open Banking. This would have to be integrated with the coverage of the other aspects of an open data ecosystem as it applies to sectors of financial services that go beyond transactional banking.

The domains overlap with fintech and the intersection is important, but it is only a narrow intersection. There are incumbent financial services firms (i.e. "non-fintechs") who do/will operate in Open Finance, and there are "fintechs" who have no relation to Open Finance applications. Smart Data Foundry suggest the critical piece for the curriculum is the teaching of business models and data-driven strategies aimed at Open Finance entities. Future emoluments of the curriculum could incorporate a mini-strategy course drawn from an MBA curriculum but focused on the aspects of building and scaling an innovative data-driven business operating in an Open Banking and Open Finance ecosystem.

There is the conflation of analytics in financial services with analytics in business in general. This is partly captures by the data science elements needed e.g. the need to code, clean data, use an API, understand the differences needed in a computational environment if it is to cope with large-scale datasets or high-performance compute tasks (AKA "Big Data"). The challenge, in a critique from Smart Data Foundry, is to know at what point the Open Finance curriculum stops. After all, they point out that the proposed curriculum can't replicate the full scope of specialist degrees in these areas (of which there are many).

The insights into the various required skills also leads us to ask whether these should be incorporated into a 3-year Undergraduate program rather than a one year Masters. The identified modules suggests some generic business skill components, core finance elements, and some computing and data modules. The answer therefore appears to be that the design and duration of programs designed specifically for Open Finance should be at the Masters level, building on a data science undergraduate background or as a part time course for industry professionals already exposed to Open Finance. We do, however, think that the Masters program could be provided as a flexible pathway with exit points at the postgrad certificate and diploma (Barnett (2014)).

Where possible, we suggest authentic, real-world experience, be included in the learning content with cases and problems that learners can relate to. The inclusion of work placement might be considered controversial. We found that the finance industry favours this approach as it fosters

relevant learning, collaboration, critical thinking, and communication (Lombardi and Oblinger (2007).) Further, it helps address the high degree of latency in content.

The latency of content will present the curriculum with the challenge of being updated frequently. There remain a number of areas in Open Finance that continue to evolve (Broby (2021)). These include access control by authorized users. Financial companies face the problem of encrypting large data sets. This is particularly true in end-to-end communication. The data anonymization process is also evolving. This requires an understanding of the vulnerability of that data and how to handle dynamic rather than static data sets. Another area of ongoing debate is how machine learning techniques can be adapted to the large data sets used in financial institutions.

Part of the latency debate is the move to cloud storage. This represents a challenge to proponents of Open Finance. It should be observed, however, that such a move is not necessarily bad for Open Finance. With centralized storage in a financial service company, there remains a possibility of a single point of failure threatening the entire data set. This is not the case with cloud storage. That said the security risks related to cloud storage and similar issues can be addressed within the taught element of the IT modules.

We suggest the curriculum also address the issue of Education for sustainability (QAA, Advance HE, 2021). An industry facing curriculum should draw on indicative themes that align with the 17 Sustainable Development Goals proposed by UNESCO in 2013. With Open Finance, we see this being incorporated into the course within the spheres identified by Tilbury & Wortman (2004) of environment, society and economy.

Finally, we acknowledge that developing a new master's program requires time and effort of designing, approval, development and testing. As such, the speed of uptake will likely differ from institution to institution.

6 Conclusion

This paper has presented a case for curriculum innovation based on identifying a body of knowledge in Open Finance. It presents the design of a master's level course developed using ICDF. Data and financial analytics lie at its core. It also presents the curriculum formulated using Barnett and Coate's (2005) curricula domain model . The resultant course would fill a skills gap in the financial sector and deliver a transdisciplinary offering. In order to achieve a good pedagogical outcome, we present a description of the essential skills, knowledge, and attitudes required to make those that follow the curriculum effective graduates. The authors hope that the perspectives shared will lead to more tailored content for students to pursue a career in Open Finance.

We argue that infusing curricula from finance and technology content delivers a holistic subject offering, thereby providing a unique combination of skills. These include technical, programming, data analytics, information technology and transferable skills. The resultant output transcends these separate specializations and delivers an educational offering in Open Finance that defines it as a new subject area in its own right.

The curriculum in Open Finance addresses the skills identified in the third edition of World Economic Forum (2020) "Future of Jobs" report. In particular, these skills include analytical thinking, complex problem solving and the use of technology. The proposed curriculum is also aligned to the OECD Learning Compass 2030 (2019), the components of which include our core modules, specialist modules, finance knowledge, IT skills, banking attitudes and ethical values.

In our research, our engagement with Smart Data Foundry found that industry requires graduates who are able to identify and classify data and be able to analyse and implement required technical solutions. We suggest a combination of practical data skills and the elements of taught finance as relate to time series and cross-sectional data. These are supported by an understanding of data privacy and Internet security protocols. we further recommend an element of integrated work experience, focused on data centered tasks. The proposed curriculum therefore encompasses a variety of real world employment problems as well as taught subjects, all of which currently exist in some form in higher education institutions

In summary, we propose a professionally relevant master's level course designed from several disciplines to meet the needs of Open Finance companies and those wishing to make a career in this new and fast-growing field. The curriculum and learning outcomes transcend the finance and technology disciplines, thereby creating a new academic discipline termed Open Finance.

References

Acemoglu, D., & Autor, D. (2011). Skills, tasks and technologies: Implications for employment and earnings. Handbook of labor economics, Vol. 4, 1043–1171. Elsevier.

Aeschleman, S.R., & Gedig, K.S. (1985). Teaching banking skills to mildly mentally retarded adolescents. Applied research in mental retardation 6 (4): 449–464.

Archer, W. & Davison, J. (2008). Graduate employability. The council for industry and Higher Education 1–20.

Barnett, R. (2014). Conditions of Flexibility: Securing a More Responsive Higher Education System. Higher Education Academy.

Barnett, R. & Coate, K. (2005). Engaging the curriculum in higher education (Berkshire, Society for Research into Higher Education & Open University).

Barnett, R. (2009). Knowing and becoming in the higher education curriculum. Studies in higher education 34 (4): 429–440.

Bartholomew, P. & Curran, R. (2017). Translating institutional approaches to curriculum design into practice–A leadership perspective. In Learning-centred Curriculum Design in Higher Education, 29–68. Libri Publishing.

Biggs, J. (2003). Aligning teaching for constructing learning. Higher Education Academy 1 (4).

Biggs, J. & Tang, C. (2011). Teaching for quality learning at university. McGrawhill education (UK).

Broby, D. (2021). Financial technology and the future of banking. Financial Innovation 7 (1): 1–19.

Brodsky, L. & Oakes, L. (2017). Data sharing and open banking. McKinsey & Company 1097–1105.

Carrithers, D. Ling, T. & Bean, J. C. (2008). Messy problems and lay audiences: Teaching critical thinking within the finance curriculum. Business Communication Quarterly 71 (2): 152–170.

Cox, S. & King, D. (2006). Skill sets: an approach to embed employability in course design. Education+ Training.

DeMong, R.F., Pettit, L.C. & Campsey, B.J. (1979). Finance curriculum for the future: perceptions of practitioners versus academicians. Journal of Financial Education 45–48.

Drummond, I., Nixon, I.& Wiltshire, J. (1998). Personal transferable skills in higher education: The problems of implementing good practice. Quality assurance in education . Durkheim, E´., Halbwachs, M. & Dubet, F. (1938). L''evolution p´edagogique en. France. Vol. 2. F. Alcan.

Duval, E. (2011). Attention please! Learning analytics for visualization and recommendation. In Proceedings of the 1st international conference on learning analytics and knowledge, 9–17.

Ellis, R. (1993). The management of quality in the University of Ulster. Higher Education 25 (3): 239–257.

FCA. (2018). Financial Conduct Authority Call for Input: Using technology to achieve smarter regulatory reporting. .

Fichman, R.G., Dos Santos, B.L. & Zheng, Z. (2014). Digital innovation as a fundamental and powerful concept in the information systems curriculum. MIS quarterly 38 (2): 329–A15.

Healey, M. (2005). Linking research and teaching: disciplinary spaces. Reshaping the university: new relationships between research, scholarship and teaching 30: 42.

Henze, M., Matzutt, R., Hiller, J., Muhmer, E., Ziegeldorf, J.H., van der Giet, J. & Wehrle, H. (2020). Complying with data handling requirements in cloud storage systems. IEEE Transactions on Cloud Computing.

Hussain, K. & Prieto, E. (2016). Big data in the finance and insurance sectors. In New horizons for a data-driven economy, 209–223. Springer, Cham.

Kambatla, K., Kollias, G., Kumar, V. & Grama, A. (2014). Trends in big data analytics. Journal of Parallel and Distributed Computing 74 (7): 2561–2573.

Karkkainen, T., Panos, G.A., Broby, D. & Bracciali, A. (2017). On the educational curriculum in finance and technology. In International Conference on Internet Science, 7–20. Springer.

Kemp, I.J. & Seagraves, L. (1995). Transferable skills—can higher education deliver? Studies in Higher Education 20 (3): 315–328.

Ko, A.J., Myers, B.A. & Aung, H.H. (2004). Six learning barriers in end-user programming systems. In 2004 IEEE Symposium on Visual Languages-Human Centric Computing, 199–206. IEEE.

Lombardi, M.M. & Oblinger, D.G. (2007). Authentic learning for the 21st century: An overview. Educause learning initiative 1 (2007): 1–12.

Matt, C., Hess, T. & Benlian, A. (2015). Digital transformation strategies. Business & information systems engineering 57 (5): 339–343.

McKenna, J.F., Cotton, C.C. & Van Auken, S. (1995). Business school emphasis on teaching, research and service to industry: Does where you sit determine where you stand. Journal of Organizational Change Management .

McWilliams, V. B., Pantalone, C.C. (1994). Structuring the finance curriculum: a survey. Financial Practice and Education 4 (1): 37–46.

Mechtley, A. (2020). API as Curriculum: Designing High-Level API Affordances as Instructional Scaffolds. In Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems, 1–9.

Mills, S. Director of Competition, The Investments and Savings Alliance (TISA) Open Finance Conference, 18 November 2019

Murphy, C, & Curran, R. (2018). Integrated curriculum design framework. Ulster University (available from: https://www. ulster. ac. uk/cherp/academic-development/icdf) .

Murphy, C. & Curran, R. (2019). Empowering curriculum leaders to innovate: an overview and evaluation of an Integrated Curriculum Design Framework. In Staff and Educational Development Association (SEDA) Spring Teaching, Learning and Assessment Conference: Collaboration to support the student experience and progression, Staff and Educational Development Association.

Null, W. 2016. Curriculum: From theory to practice. Rowman & Littlefield.

O'Neill, G., McEvoy, E. & Maguire, T. (2020). Developing a national understanding of assessment and feedback in Irish higher education. Irish Educational Studies 39 (4): 495–510.

Pridmore, J.L., Bradley, R.V. & Mehta, N. (2010). Methods of instruction and learning outcomes: A theoretical analysis of two approaches in an introductory information technology course. Decision Sciences Journal of Innovative Education 8 (2): 289–311.

Ramdani, B., Rothwell, B & Boukrami, E. (2020). Open banking: The emergence of new digital business models. International Journal of Innovation and Technology Management 17 (05): 2050033.

Ritter, B.A, Small, E.E., Mortimer, J.W. & Doll, J.L. (2018). Designing management curriculum for workplace readiness: Developing students' soft skills. Journal of Management Education 42 (1): 80–103.

Rom¯anova, I., Grima, S., Spiteri, J. & Kudinska, M. (2018). The payment services directive 2 and competitiveness: the perspective of European Fintech companies. European Research Studies Journal 21 (2): 5–24.

Rousseau, H.P. (2019). GDPR, PSD2 and open banking are creating a new dynamic in personal financial services: A note. Journal of Internet Banking and Commerce 24 (1): 1–7.

Russo, A., Warren, L., Neri, L., Herdan, A. & Brickman, K. (2021). Enhancing accounting and finance students' awareness of transferable skills in an integrated blended learning environment. Accounting Education 1–25.

Tilbury, D. & Wortman, D. (2004). Engaging people in sustainability. IUCN.

Van Wijk, J.J. (2005). The value of visualization. In VIS 05. IEEE Visualization, 2005., 79–86. IEEE.

Quality Assurance Agency for Higher Education and Advance HE (2021) Education for Sustainable Development Guidance. Gloucester: The Quality Assurance Agency for Higher Education. Accessed via web, March 2022. https://www.qaa.ac.uk/quality-code/education-for-sustainable-development.

QAA (October 2014) UK Quality Code for Higher Education. Part A: Setting and Maintaining Academic Standards. The Frameworks for Higher Education Qualifications of UK Degree-Awarding Bodies (October 2014). Available from http://www.qaa.ac.uk/assuring-standards-and-quality/the-quality-code/subject-benchmark-statements.

QAA. Higher Education Credit Framework for England: Advice on Academic Credit Arrangements. 2nd Ed. (May 2021). Available at: https://www.qaa.ac.uk/quality-code/higher-education-credit-framework-for-england

QAA (n.d.). UK Quality Code for Higher Education: Subject Benchmark Statements. Quality Assurance Agency. Available from http://www.qaa.ac.uk/assuring-standards-and-quality/the-quality-code/subject-benchmark-statements.

Zachariadis, M. & Ozcan. P. (2017). The API economy and digital transformation in financial services: The case of open banking.