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Designing Microcurricula-as-a-service: The case of large class, cross programme, and online asynchronous module

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Abstract

Repurposing higher-education curriculum to tailor to the needs of learners is becoming common in response to recent societal and technological changes. Designing existing and new modules into microcurriculum is taking place with the objective of delivering very specific knowledge and skill set based on the requirements of learners. This paper outlines the design of Microcurricula-as-a-Service (MaaS) based on "As-a-Service" principle borrowed from the software engineering domain. The paper presents the design of a Data Literacy and Analytics (DLA) module at Dublin City University under the DCU Futures programme as a case study. DLA is an online and asynchronous module designed for ten DCU Futures programmes, embedded into 34 standard modules, and delivered to eight hundred first- and second-year students in the 2022/23 academic year. The module consists of 14 carefully selected data literacy and analytics microcurricula worth 0.5 to 1 ECTS. This paper further demonstrates that MaaS can furnish microcurricula focused on specific topics, that are self-contained, composable, flexible, scalable, and economical. MaaS can be composed into large credits catering for the requirements of individual programmes, or embedded into other modules maintaining high quality at a lower cost.

Keywords: *Microcurricula-as-a-Service, Microcurriculum design, Data Literacy, Data Analytics*

1. Introduction

Curriculum design has always been at the heart of the higher education sector (Clayton & Clopton, 2019). Universities revisit their curriculum to reflect their mission and stay up to date to meet the changing requirements of learners, employers, industry partners, and other stakeholders. In recent years, curriculum design demonstrated a significant shift from the traditional classroom-based delivery of education to a more targeted, flexible, self-paced, and large class delivery using online, synchronous or asynchronous modes. The pandemic further contributed towards the wide adaptation of such curriculum in third-level education (Bashir et al., 2021, Turnbull et al., 2021, Farell et al., 2021).

Another recent global development deals with the prevalence of data in a data-driven culture and its application demanding educators to focus on producing data-literate workforce equipped with competency skills that are required to navigate through the ocean of data (Vuorikari et al., 2022). There is a growing demand for data literacy and analytics skills both from employers and learners alike in all disciplines that consume data. To meet this demand, universities are focusing on equipping learners with data literacy and analytics skills by designing modules to respond to the growing demand. Data literacy equips learners with the knowledge, tools and techniques they require to successfully utilise the benefits of data and its analytics. Data literacy and analytics in the 21st century become a common denominator among multiple disciplines that deal with data and its analytics. Data literacy and analytics is often delivered across multiple programmes with a very large number of learners subscribing for one or more aspects of the subject.

DCU has long recognised this requirement and established DCU Futures[1] to empower students to be future-capable and to traverse through the unscripted world defined by unprecedented technological and social change. DCU Futures is an HCI-funded project which aims at re-imagining undergraduate education focusing on transversal skills including data literacy, digital literacy, language skills, creative thinking, health literacy, and others that are identified as transversal skill sets. Data literacy and analytics is one of the skill sets incorporated into the programme and identified as a core skill set to be delivered to ten participating DCU Futures programmes.

[1] https://www.dcu.ie/ovpaa/dcu-futures

2. Description of the Teaching/Learning Context

This paper presents an approach for designing microcurricula using a MaaS design approach. The microcurricula are developed for Data Literacy and Analytics (DLA) under the DCU Futures initiative for all participating programmes. The DLA module, which is designed by applying the MaaS approach and is being delivered to 805 students in an online and asynchronous setting is presented as a case study.

2.1. MaaS

MaaS is an approach borrowed from a software engineering domain known as Software-as-a-Service (SaaS) (Schütz et al., 2013) and microservices design (Newman, 2015). SaaS focuses on providing specific software as a service by a software provider taking care of the design, implementation, and management of a small unit of software (microservice) that does a single task. In SaaS, two or more microservices can be composed into a big software service. Each microservice is responsible for a single task and can be embedded into other services.

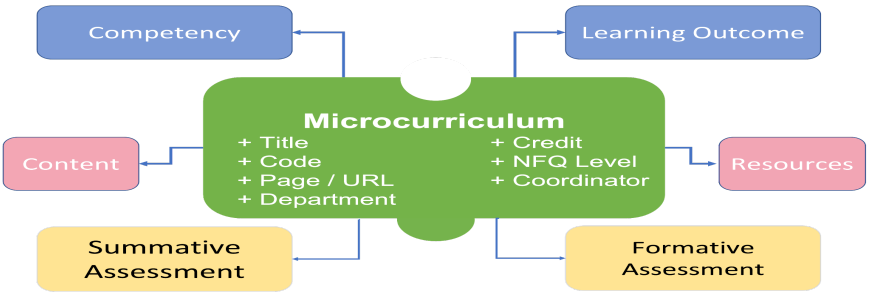

Figure 1. Microcurriculum-as-a-Service skeleton and components.

Analogous to SaaS, MaaS focuses on designing a microcurriculum that delivers a single cohesive and self-contained topic with a single competency, learning outcome, activities, assessment, and microcredits in European Credit Transfer and Accumulation System (ECTS) (European Commission, Directorate-General for Education, Youth, Sport and Culture, 2017). A module designed as MaaS can be embedded into other modules or can be composed into larger credits (2.5, 5, 7.5 or 10 ECTS) depending on the requirements of the programmes. Figure 1, presents the skeleton of a MaaS along with its major components. The module coordinator (provider) is responsible for the development and management of the MaaS and making it available for clients (in this case, other module coordinators) to reuse the MaaS in their modules. A microcurriculum contains a single competency and

learning outcome with coherent content and resources specifically tailored to achieve the learning outcome along with one or more formative and summative assessments.

2.2. Case Study: Data Literacy and Analytics Module

DCU's data literacy and analytics expert working group, which is composed of academics and operational staff across the university, defined data literacy as the capability to process, critique, analyse, visualise, and interpret data in an unbiased, responsible, actionable, and ethical manner. Following a consultation of the industry partners and academic stakeholders, the data literacy and analytics working group identified 14 core topics (later treated as microcurricula) that are deemed to be critical skills for DCU students (see Figure 2). The working group contributed towards the definition of the competency levels and learning outcomes for the identified curricula. Each microcurriculum (identified hereafter as DLAT) has an estimated ECTS workload, where one ECTS credit corresponds to 25 hours of work (DCU Marks and Standards, Version 2021.1, Section 2.1.1). This workload includes online lecture hours, practical/lab hours, any tutorials and independent study hours. The corresponding ECTS of each microcurriculum along the topics covered is depicted in Figure 2.

Four of the 14 microcurricula (Introduction to Data Literacy, Introduction to Big Data Analytics, Data Protection and Ethics, Database Modelling) focus on theoretical and fundamental concepts that are mandatory while the other three nine microcurricula focus on data analytics and visualisation tools delivered using three routes: Spreadsheet, Python, and R. For example, Introduction to Spreadsheet, Intermediate Spreadsheet, and Data Visualisation using Spreadsheet are included under the Spreadsheet route. These three routes allow DCU Futures programmes to select one or more tools to teach students based on their disciplinary requirements. It further allows students to specialise in two or more data analytics tools of their choice. The last microcurriculum (Introduction to Statistics) is also available to students as an introductory statistics topic. Each microcurriculum has been embedded into 34 standard DCU modules during the 22/23 academic year. For example, CS218 embeds DLAT1 and 2, whereas CS207 embeds DLAT 3, 5, 6 and 7.

A 5 ECTS stand-alone module (CA179) is composed of the four mandatory microcurricula and three additional microcurricula using the Spreadsheet route. While two DCU Futures programmes chose the 5 ECTS stand-alone module, eight programmes decided to embed these microcurricula into their core modules. One programme chose to go along with the R route while another programme selected the Python route.

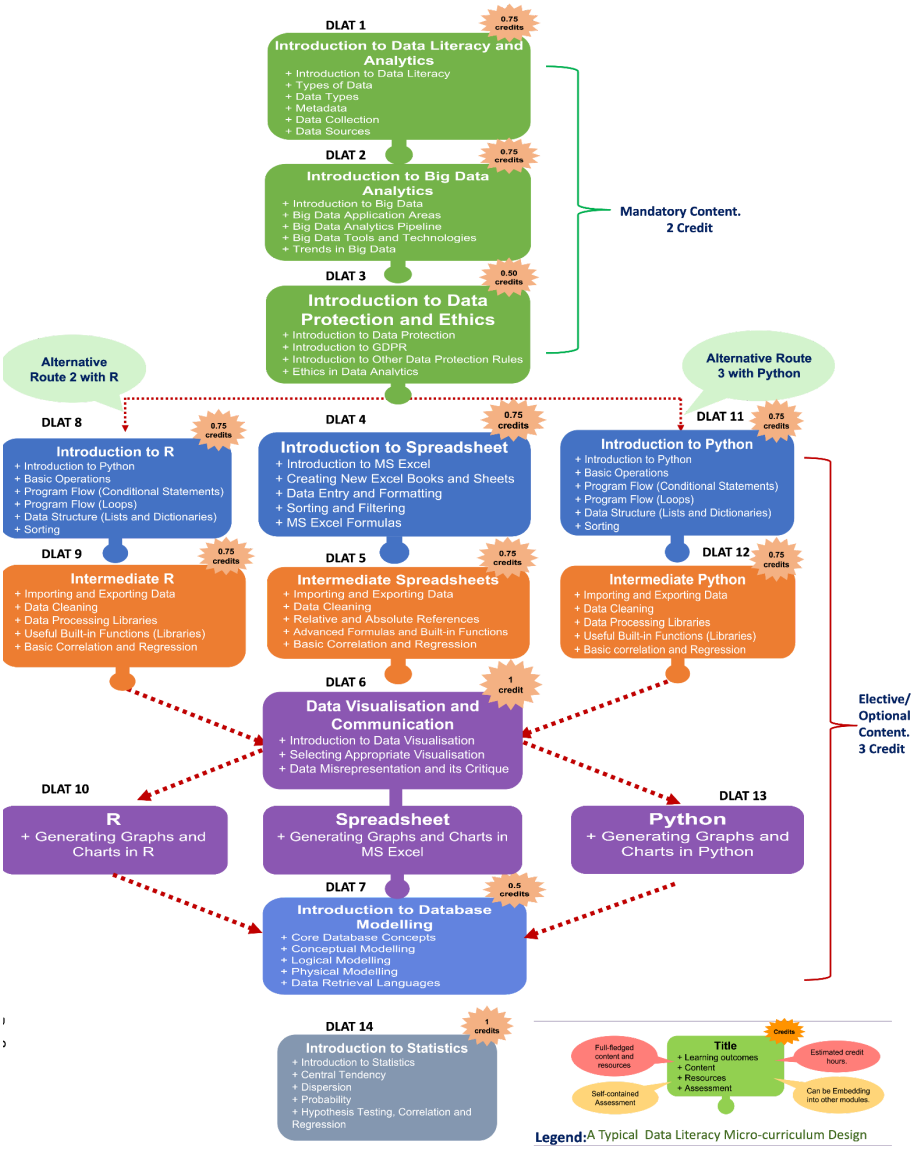

Figure 2. Data Literacy and Analytics for 21st Century Microcurricula-as-a-Service.

The content in each microcurriculum is designed based on inputs from several experts in the area of data literacy and analytics, industry experts, and other stakeholders. The content is produced at a higher standard and implemented in Loop (DCU's virtual learning environment) mostly using H5P books, expert interviews (fireside chats) and high-quality

reference materials. The content is developed following the ABC learning design principle and incorporates the acquisition of knowledge, collaboration, discussion, investigation, practice, and collaboration (Hasenknopf et al., 2019, Young & Perović, 2020). The design incorporates most of these tasks explicitly in the module. However, it gives lesser emphasis to collaboration which is a challenge in an online asynchronous environment (Smyth et al., 2021) and requires additional efforts to achieve it (Fabriz et al., 2021). Each microcurriculum has its own online asynchronous summative assessment which is made available as soon as a student completes all the subtopics and the peer-learning activities. The assessment questions are derived from a large set of question banks using a stratified random sampling method where each stratum represents the subtopics of the microcurriculum.

3. Literature Review

Designing a curriculum targeting a large cohort of heterogeneous learners requires meticulous planning and execution (Laurillard, 2010). The design should take into consideration major issues including the aim, topics, learning outcomes, learning time, assessment, staffing and the number of students. The 21st-century curriculum further looks into approaches that deliver composable, flexible, and scalable curricula reflecting the requirements of users and considering state-of-the-art educational technologies.

Microcurriculum design has become a common curriculum design option related to the development and delivery of specific content within a topic targeting niche learner groups to attain specific knowledge and skills ((Li, 2018; Robertson, 2021). The approach relies on current educational technologies and online environments to reach a large number of learners in both synchronous and asynchronous modes (Jin, 2020; Farell et al., 2021).

Recently concepts borrowed from other disciplines provide alternative ways of designing microcurricula. One of the approaches considers microcurricula as a service analogous to Software-as-a-Service (SaaS) paradigm. Although the As-a-Service approach is being used across many disciplines, it is not a widely used concept in curriculum design. Different scholars are proposing the use of Microcurricula as a service in higher education settings (Ashraf & Alanezi, 2020).

4. Empirical Methodology/Data

The DLA module targeted more than 805 DCU Futures students in the 2022/23 academic year from ten programmes under four of the five faculties in DCU. The delivery of the module was in a fully asynchronous and online mode. The module was delivered to two

DCU Futures programmes as a 5-credit stand-alone module: BSc in Bioprocessing (BP) and BA in Climate and Environmental Science (BCES). Both programmes opted for the spreadsheet route. BCES students took an additional Introduction to Statistics topic to introduce them to the core concepts of statistics for data analytics. Thirty-four modules (first, second, and year-long semesters) embedded the microcurricula as part of their modules. All programmes embedded the core microcurricula, while the majority of the programmes subscribed to the spreadsheet route, one programme subscribed to the Python route and another programme subscribed to the R route. Module coordinators who embedded these topics are responsible for the smooth integration of the topics in their overall module content and ensuring the students complete the topics they embed in their modules. For the two programmes that took the stand-alone module, the DLA module coordinator provided face-to-face synchronous tutorials to ensure their engagement with the content.

Table 1 shows the number of learners and module coordinators per microcurriculum with the last column showing the total number of unique users. Since 34 modules embedded one or more microcurricula, the respective module coordinators are added as non-editing teachers. This role allows them to review and follow up the progress and results of their respective students.

Table 1. The distribution of students and module coordinators in each microcurricula

Role	DLAT1	DLAT2	DLAT3	DLAT4	DLAT5	DLAT6	DLAT7	DLAT8	DLAT9	DLAT10	DLAT11	DLAT12	DLAT13	DLAT14	Total (Unique)
# Students	646	644	710	723	730	567	707	16	16	16	25	25	25	79	**805**
# Teacher & non-editing Teachers	28	30	39	33	31	34	29	2	2	2	10	10	10	10	**59**
Total (Unique)	**674**	**674**	**749**	**756**	**761**	**601**	**736**	**18**	**18**	**18**	**35**	**35**	**35**	**35**	**864**

Preliminary statistics collected from the interaction of the students at the end of the first semester indicated a higher level of engagement and participation from the students. Self-assessment questions posed at the beginning of each module show that there is a strong need for data literacy and analytics knowledge. Parallel questions asked at the end of each microcurriculum further indicate that the students' knowledge and skill set have improved due to the delivery of these topics. A more systematic analysis of the data is underway, however, the full result of the study will only be available at the end of the academic year 2022/23.

Module coordinators also indicated that the MaaS approach is flexible enabling them to make the microcurricula available to students on their own schedule at any time in the academic year independent of the class size. It further saves the time and effort of the module coordinators in preparing and delivering the module and conducting a summative

assessment of the module. Following the success of the first semester, seven module coordinators who are not part of the DCU Futures programme have also embedded the microcurricula in their second and third-year modules.

5. Analysis of/Reflection on/Implications for Practice

DLA demonstrates the potential of designing microcurricula based on the MaaS principles in that it is highly scalable, flexible, composable, and independent. Among the many benefits of MaaS, the following features are worth mentioning.

Scalability: the scalability of the module comes in two dimensions. First, since each microcurriculum is organised as separate module instances, it is possible to add or remove new topics based on the requirements of the programmes without affecting other microcurricula. Second, since the resources to the microcurricula are delivered in an asynchronous and online environment, it is demonstrated that the module is scalable in terms of accommodating a large number of enrolled students.

Self-contained and independent: this aspect emanates from the structure of each microcurriculum. The microcurriculum is structured to cover a single cohesive topic which is decoupled from other topics. A microcurriculum also has independent activities, resources, assessments with pass/fail marks, and most importantly estimated ECTS. Thus, each of the 14 microcurricula can be viewed as an independent self-contained microcurriculum which can be delivered to students independently.

Composable: The microcurricula are related to each other and the knowledge of one microcurriculum could be a basis for another. In circumstances where there is a need to build these independent topics into a stand-alone full-fledged module, it is possible to compose the microcurricula into 2.5, 5.0, 7.5 or 10 ECTS modules. Although we propose practical precedence of the topics, the microcurricula can be taken in any order that suits the learner starting from the basics to progressing to the advanced topics.

Embedded: These microcurricula are organised in such a way that the topics (even the subtopics) are suitable to be embedded in other modules. For example, a 2.5 credit Introduction to Spreadsheet which is composed of the three topics (Introduction to Excel, Intermediate Excel, and Data Visualisation with Excel) is embedded into a "Visualisation & Validation of Laboratory Data" module claiming the 2.5 credits. In another instance, Introduction to Big Data Analytics is embedded into a "Chemistry Lab & Spectroscopic Workshop" module claiming 0.75 credits. When the microcurricula are embedded, it allows

the module coordinators to reuse all the resources without reinventing the wheel which significantly reduces the time required to prepare the same content across several faculties and departments.

Economical: data is ubiquitous and so is the demand for data literacy and analytics. Universities with several thousands of students and a significant number of programmes require to include data literacy and analytics microcurricula in their programmes. Doing this individually will result in duplication of effort and waste of resources. MaaS addresses this issue by designing high-quality microcurricula centrally and reusing them across several modules and different programmes. This approach can be extended to other modules that are delivered across multiple programmes.

Although these are some of the benefits, our implementation of DLA using MaaS also comes with its own disadvantages. First, there is no single size fits all solution that works for all programmes. To reduce this problem, we ran several workshops and consultation meetings with programme chairs to select the topics and the learning outcomes. We provided multiple options to deliver the required topics for programmes. The options included several levels of customisation of the content to satisfy the requirements of different programmes by inviting subject matter experts from different backgrounds and incorporating discipline-specific content to make the module relevant to the students. The customisation challenge is also reflected in the preparation and delivery of the content on Loop (our learning platform).

Second, the summative assessment required dealing with academic integrity. With many students taking the online asynchronous assessment, there was an ongoing risk that students could share answers among their circles. To avoid this, we prepared large question banks and randomised the questions to ensure students got different sets of questions. Even If the solution did not completely remove the challenge, it has significantly reduced the risk. Third, the formative assessment required a considerable time to provide individual feedback to the students. The scale of participation in the peer-learning activities and discussion forums posed a significant challenge to the module coordinator to give individual feedback and required additional scalable solutions.

Above all the challenges, early-stage data and informal feedback from the students indicate that the MaaS design is working well with promising results. Future work in the area will look into the standardisation and dissemination of the MaaS approach using semantic models (Abgaz et al., 2018, Phal et al., 2010,) to make it available for the wider academic community.

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