# Developing Digital Leaders

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## A Report of the Current State of Digital Topics in Undergraduate and Graduate Business Curricula

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MaCuDE
Management Curriculum for the Digital Era

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# Management Summary

"Management Curriculum for the Digital Era" (MaCuDE)[1] is a research project focused on assessing the current state of business school curricula for "digital readiness" and developing recommendations for their evolution to address the challenges and opportunities of the digital era. The project was chartered by the Digital Transformation Affinity Group of AACSB[2] in 2019 to examine changes brought about by the emergence of digital topics such as Artificial Intelligence and Big Data Analytics and their impact on skills expected from business school graduates. After a planning phase in fall 2019, the project started in January 2020 and is expected to run until mid-2023.

The MaCuDE project is structured in three major phases:

- Phase 1: Assess the current state of digital themes in business school curricula
- Phase 2: Identify knowledge and skill requirements as expressed by industry
- Phase 3: Develop recommendations for curricular evolution

This report summarizes the findings of Phase 1.

We found five key themes brought about by the evolution of digital technologies: Data Analytics and Machine Learning, Programming, Algorithms and Artificial Intelligence, Emerging Digital Technologies, and Managing Digital Organizations. As a result, business school graduates of the Digital Era should be able to make sense of and create value from data, be able to develop tools that allow them to streamline and scale their contribution to their organization, be able to leverage the potential of artificial intelligence and automation technologies and be able to manage organizations that base their business model on digital capabilities.

Our analysis of existing business school curricula reveals that many business schools are responding to these emerging skill requirements by introducing courses on data analytics, programming, and disciplinary digital topics in their general management curriculum as well as in specialty Masters programs. That said, most courses identified by our project address the operational and tactical application of digital technologies. To the extent that digital technology changes the way we work, collaborate, and manage organizations, we found fewer examples that address emerging changes at the managerial and strategic levels.

In Phase 2 of this project, we will collect input from industry representatives as to what their perceived skill gaps are in business school graduates and what changes they would like to see in business school curricula. Phase 3 will synthesize the insights from Phase 1 and 2 and deliver recommendations for digital-ready business school curricula.

1. The authors gratefully acknowledge the financial contribution of PwC toward the MaCuDE project, as well as the organizational and logistical support of AACSB.

2. For more information on DTAG refer to https://www.aacsb.edu/educators/membership/networking-communities

# 1. MaCuDE Project Overview

## 1.1. Introduction to the MaCuDE project

Business programs should prepare students for the sweeping changes taking place today, mainly because of the rapidly emerging digital technologies, such as the Internet of Things (IoT), artificial intelligence (AI), robotics, Blockchain, virtual and augmented reality, and more. These technologies are radically transforming areas of cognitive and physical work, opening up new opportunities for complex decision-making and efficiency improvement, and creating a new mindset and a new set of skills that students need to possess to be competitive and successful. In this digital era, future managers will need to work alongside intelligent machines that perform many cognitive tasks that were hitherto performed exclusively by humans. Many traditional business roles are disappearing, and new roles are emerging. Competition is no longer confined to strict industry boundaries. A new style of leadership is emerging where digital savviness is essential. New ethical issues arise, and decision-makers find themselves in unchartered waters facing unprecedented dilemmas.

The AACSB Digital Transformation Affinity Group, under the leadership of Stevens Institute of Technology (Stevens), has undertaken a project to revise the Management Curriculum for the Digital Era (MaCuDE). The project is sponsored by the Association for the Advancement of Collegiate Schools of Business (AACSB International) and is funded by PwC. After a planning phase in fall 2019, the project started in January 2020 and is expected to run until mid-2023.

## 1.2. MaCuDE Project Structure

The MaCuDE project is a collaboration of over 100 universities[3] across five continents. The work of the project is organized in nine task forces, each comprised of 10-20 participating universities and led by one or two institutions. Six of these task forces are aligned with traditional academic disciplines, while three are "horizontal" in that they cross over multiple domains and functions.

The six disciplinary task forces are:

- Accounting, led by the University of Virginia and University of Southern California
- Finance, led by Imperial College in the UK
- Information Systems, led by Case Western Reserve University
- Management, led by Rensselaer Polytechnic Institute
- Marketing, led by Northwestern University
- Strategy, Innovation, and Entrepreneurship, led by IIM Bangalore in India

Three task forces that are cutting across traditional disciplines and are chartered to explore themes that transcend disciplinary boundaries are:

- Analytics/Operations Research, led by Georgia Tech University
- Ethics and Cybersecurity, led by the University of Pennsylvania
- The Future of Work, led by the University of Turku in Finland

3. For a list of members refer to https://www.macude.org

# 2. General Findings

## 2.1. Common Themes of the Digital Era

The Digital Era is characterized by five key developments, which are also reflected in the curricula of business schools:

- **Data Analytics and Machine Learning.** The Digital Era brings a rapid increase in data that is available for decision-making, whether obtained through manual processes or through automated sources such as sensors and other technical devices (Big Data). Methods and tools to collect, integrate, and analyze this data are becoming ever more sophisticated, to the extent that the preparation and analysis of data take place without human intervention, for example, through the use of Machine Learning techniques. Consequently, business graduates need to be familiar with data analytics techniques and understand the impact that Machine Learning will have on organizations. Most schools have already introduced courses on Big Data and Analytics, while a significant number of schools have also introduced Machine Learning and other related courses across several disciplines.

- **Programming.** The use of software development tools has spread beyond the confines of Computer Scientists and Software Engineers. Whether it is the programming of macros in standard office software, the design of data analysis scripts using languages such as Python and R, or the configuration of personal workflows using low-code tools, we see the emergence of "citizen developers" that solve specific problems in their workplace without a formal Computer Science background. As a result, business graduates should be familiar with some programming skills. Already, many schools have introduced coding courses in their business curricula (including their core MBA), either as stand-alone courses, as lab courses, or as prerequisites for their courses.

- **Algorithms and Artificial Intelligence.** As the volume of available data increases, so increases the need to generate insights from data at scale and to leverage these insights in a responsive and agile fashion. Organizations are no longer reacting to requests from customers; they are tasked to anticipate what customers might want before they are even aware of it. Recommender systems use historical data to create highly personalized suggestions for users of streaming video services or e-commerce sites. Sentiment analysis in call centers provides agents with real-time insights into the mood of their callers. And before agents get involved, automated chat-bots are fielding routine customer inquiries at scale, freeing up human capacity to solve more challenging problems. Business School graduates need to understand how algorithmic solutions and Artificial Intelligence create opportunities for value creation in organizations. Already, a number of schools have introduced courses on the development of algorithms and of Artificial Intelligence solutions, as well as managing these solutions in the enterprise.

- **Emerging Digital Technologies.** The Digital Era brings about new technologies that, on the one hand, integrate and improve several distinct technology streams and, on the other hand, create entirely new capabilities. Robotic Process Automation is an example of the former, as it combines scripting, optical character recognition, and

**Five Key Themes of the Evolution of Digital Technologies**

- Data Analytics and Machine Learning
- Programming
- Algorithms and Artificial Intelligence
- Emerging Digital Technologies, and
- Managing Digital Organizations

workflow automation to automate desktop procedures that used to require human labor. At the other end of the spectrum are developments such as Blockchain and Crypto Currencies, which offer applications such as smart contracts that do not require intermediaries, asset management with trusted historical records of ownership, and other applications that disrupt established industry structures. Business School Graduates need to be aware of the potential of these emerging technologies and develop a technology "radar" that helps them scan for new developments in a systematic fashion. A small number of schools have introduced courses on some of the emerging technologies.

**Data literacy is a requirement of all business school graduates, no matter their major or graduate concentration.**

- **Managing Digital Organizations.** Cybersecurity and ethics are gaining in significance when managing an enterprise in the digital era. In addition, as a result of the trends described above, new organization forms have emerged, such as platform companies. These new organizations scale quickly, rely heavily on the use of data and algorithms and comprise new jobs that differ in scope, scale, and skill requirements from more traditional occupations. Business graduates need to be prepared to manage digital organizations. There is a number of courses already in business schools on the topics of cyber and ethics, as well as on digital strategies, digital transformation, competition in the digital era, and so on.

Each of these five developments has an impact on skills that are expected from business school graduates. In the following sections, we address these skill requirements in more detail.

### 2.1.1. Theme 1: Data Analytics and Machine Learning

Data-driven decision-making puts an emphasis on evidence-based management across all levels of an organization, complementing and sometimes displacing common practices that so far have relied on heuristics, tradition, or individual judgment. As the generation of data accelerates across all areas of business, decision-makers need to know where to obtain data, whether they can trust the data, and understand what the data represents.

In order to facilitate data-driven decision-making, individuals are expected to be familiar with the lifecycle of information, i.e., develop a sense of data literacy:

- Data Collection, i.e., the identification of data sources, the collection of data through quantitative and qualitative means (e.g., sensors, surveys, and interviews), the establishment of trust and credibility of data, the formatting of data for downstream consumption. An example of such a course is "Marketing Research Design and Analysis "at the University of Michigan's Ross Business School[4].

- Data Integration, i.e., the identification of complementary data sets, the correlation of data across different sources, and the transformation and integration of data in different formats. An example is the elective course "Data & Information Quality" in Stevens Institute of Technology's Business Intelligence & Analytics Master's program[5].

4. https://michiganross.umich.edu/courses/marketing-research-design-and-analysis-2904
5. https://www.stevens.edu/sites/stevens_edu/files/BIA_664_Data_Information_Quality.doc

Put simply: Data literacy is a requirement that transcends disciplinary boundaries and is a requirement of all business school graduates, no matter their major or graduate concentration. While many disciplines have specific requirements that align with their specific data formats (e.g., customer data in Marketing, market data in Finance, or financial statement data in Accounting), themes such as the trustworthiness of data, technical data integration, and information visualization are cross-cutting concerns.

In the past, data literacy and data management courses were largely focused on the design and use of (relational) database systems. However, issues such as data wrangling, dealing with unstructured data, integrating disparate data sources, and developing an ability to assess the quality and utility of a data set are becoming foundational skills of business students that enable flexible and adaptable data-driven decision-making practices down the road.

Once a sense of data literacy is established, Business School graduates need to be familiar with techniques for the analysis of these data sources. This includes:

- Data Interpretation (applying manual and algorithmic techniques to assign meaning to data, validate and verify accuracy of data, select appropriate data to address organizational questions). An example of this topic is NYU's course "Data Management and Analysis."[6]

- Data Visualization (develop methods for visualizing datasets from a variety of perspectives in order to gain useful insights and identify the best solution for a given task). An example of this topic is Stevens' "Data Visualization Applications."[7]

- Storytelling with Data (presenting data visually in a persuasive way to convince an audience using a mix of numbers, images, and graphs). Examples of such courses are Kellogg's "Visualization for Persuasion"[8] or NYU's "Storytelling with Data."[9] It is interesting to note that elvtr.com is also offering a course on "Storytelling with Data."[10]

- Data-driven Decision-Making (derive the appropriate course of action based on data, develop simulation and forecasting models to evaluate different courses of action, justify decisions with relevant data sources). Many business programs contain quantitative and qualitative decision-making courses, such as Grand Valley State University's "Applied Data Analysis and Decision Making."[11]

**Data interpretation, data visualization, storytelling with data and data-driven decision making are topics that Business School graduates need to be familiar with.**

Some universities have placed a Business Analytics course in the core of their MBA program (e.g., University of Iowa); Northwestern's Kellogg has two Analytics courses in the core curriculum of their MBA[12] while others have added specialized MBAs to their program offering that include multiple data and analytics-focused courses (e.g., NYU's Tech MBA, Stevens Institute of Technology's Analytics MBA, and Northwestern's MBAi).

6. https://www.stern.nyu.edu/sites/default/files/assets/documents/Data%20Management%20and%20Analysis-Syllabus-2019-Summer_0.pdf
7. https://www.stevens.edu/school-business/masters-programs/financial-analytics/curriculum-overview
8. https://www4.kellogg.northwestern.edu/CoursePlanning/CourseCatalog/CourseCatalogScreen?courseid=207511
9. https://www.sps.nyu.edu/homepage/academics/courses/HCAT1-GC2005-storytelling-with-data.html
10. https://elvtr.com/course/storytelling-with-data
11. https://www.gvsu.edu/catalog/course/mba-601.htm
12. https://www.kellogg.northwestern.edu/programs/full-time-mba/two-year-mba-program.aspx

Business Analytics courses have also been introduced in many undergraduate programs, as well as disciplinary MS degrees, either as core courses or as electives. Some examples of undergraduate programs with Analytics courses are Stevens' major in Accounting and Analytics, NYU's track on Digital Marketing, Case Western's Marketing Analytics major, or Imperial's Finance undergraduate program. At the graduate level, many examples exist, e.g., EM Grenoble offers an Analytics course "HR Analytics and Data Practice"[13] in their graduate HRM program.

### 2.1.2. Theme 2: Programming

We have observed a shift in basic technology skills, such as the use of office applications and personal productivity tools. Office applications (for example, spreadsheets) were taught as part of foundational Information Systems courses, and up to 2010 constituted an introductory course in the AIS/ACM Information Systems reference curriculum[14]. To date, many of these personal productivity tools are taught at the high school level, and universities can expect a certain degree of technology literacy from their incoming students. This leaves room in the curriculum to teach more advanced technology subjects.

**Developing programming skills at both the undergraduate and the MBA level is becoming increasingly common. Languages like Python or R are found in many programs.**

The ability to create digital tools that drive both personal productivity and organizational efficiencies is becoming a ubiquitous skill requirement across industries and functional disciplines[15]. However, the scarcity of programming skills among college graduates[16] has led many companies to turn toward in-house training for common programming languages, such as Python.

Many universities have responded to this development by introducing programming as an elective course in their MBA curriculum. For instance, in Spring 2022, Columbia Business School will introduce "Python for MBAs"[17] as a prerequisite for technical elective courses in their MBA program. The University of North Carolina offers "Python for Business Analytics"[18] as an elective in their MBA program, and the University of Iowa's Tippie School of Business is offering "Data Programming in Python" and "Data Programming in R" as part of the Business Analytics concentration in their MBA program.[19] Programming courses can also be found in specialty master's programs. For example, Imperial College Business School teaches "Application of R for Finance" as a foundational module of the MSc in Finance curriculum.

13. https://en.grenoble-em.com/msc-international-human-resource-management-digital-age#programme
14. See Topi et al.: IS 2010 Curriculum Guidelines for Undergraduate Programs in Information Systems. ACM and AIS, 2010.
15. See for example Noonan, Laura: JPMorgan's requirement for new staff: Coding lessons. Financial Times, October 7, 2018 and Surane, Jenny: Citi Wants Analysts to Add Python to List of Languages on Resume. Bloomberg.com, June 14, 2018.
16. Notably, the same Information Systems curriculum revision that removed personal productivity tools from the curriculum also removed Application Development as a core course from the Information Systems curriculum. Insights from the first phase of the MaCuDE project indicates that such skills are very much expected of business school graduates.
17. https://www8.gsb.columbia.edu/courses/mba/2022/spring/b8154-001
18. https://onlinemba.unc.edu/academics/mba-curriculum/python-for-business-analytics/
19. https://tippie.uiowa.edu/future-graduate-students/masters-programs/business-analytics/part-time-msba/curriculum#python-req

### 2.1.3. Theme 3: Algorithms and Artificial Intelligence

While Artificial Intelligence and Machine Learning are not new topics for organizations,[20] the emergence of algorithmic approaches to problems that exceed the manual capacity of human decision-makers has accelerated in recent years. Whether financial Robo-advisors, automatic layout tools in semiconductor manufacturing, automatic generation of news releases from financial statements, or matching algorithms for rideshare riders and drivers, the scale and scope of application of these approaches has increased tremendously. As a result, new skill requirements are emerging across disciplines:

- **Creating Artificial Intelligence and algorithmic solutions.** This includes skills to develop new algorithms, integrate new data sources, and build new technical approaches to existing problems. Early adopters in this space were Financial Engineering programs, which offer courses on Algorithmic and High-Frequency trading.
- **Using Artificial Intelligence and algorithmic solutions.** This includes skills to identify application areas where Artificial Intelligence and algorithmic solutions can contribute to organizations by accelerating processes, building scale for increasing data volumes, creating consistency in behavior, among others. It includes skills to apply ready-made solutions by integrating them with existing data sources, as well as redesigning organizational processes to leverage the new capabilities provided by algorithmic solutions.
- **Managing organizations that leverage Artificial Intelligence and algorithmic solutions.** This includes skills to facilitate work with software robots, design learning experiences for participants in the absence of "on-the-job" experiences, and managing the trust between human and machine participants.

**The emergence of algorithmic approaches to problems that exceed the manual capacity of human decision-makers has accelerated in recent years.**

In the surveys conducted by the individual Domain Task Forces of the MaCuDE project, Artificial Intelligence and Machine Learning were a theme that many participants associated with the Digital Era. However, the prevalence of courses in this space varied considerably across disciplines. One discipline with a significant number of courses in this space is Finance. Algorithmic Trading and Financial Engineering have brought an influx of technology courses into traditional Finance curricula. Northwestern's Kellogg School of Business teaches "Human and Machine Intelligence" as part of the Data Analytics track in the MBA Curriculum.[21] Missouri University of Science and Technology teaches "Machine Learning and Artificial Intelligence for Business" in their Information Science & Technology program offering. Berkeley's Haas Business School offers "The Business of AI" in its MBA curriculum.[22] Stevens' School of Business has developed a course and a certificate program on the "Management of AI."[23]

**Programs and courses aim to address 2 different needs:**

- **Creating or using AI and algorithmic solutions to problems, e.g., in Financial Engineering,**
- **Managing organizations that leverage AI and algorithmic solutions.**

20. See for example the Dartmouth Summer Research Project on Artificial Intelligence which was held from June through August of 1956.
21. https://www4.kellogg.northwestern.edu/CoursePlanning/CourseCatalog/CourseCatalogScreen?coursename=MORS-950-5&_ga=2.73827602.1426383894.1642116674-1594950848.1642116674
22. http://courses.haas.berkeley.edu/descriptions/Descriptions/MBA267-11_Spring20.htm
23. https://www.stevens.edu/school-business/graduate-certificates/management-ai

### 2.1.4. Theme 4: Emerging Digital Technologies

The Digital Era has brought many technologies to the mainstream that used to be the domain of specialists or that had only limited applications in the past. Whether it is the emergence of location-based services that leverage mobile technology and sensor data, the ability to automate almost any routine task, or the evolution of blockchain technology that allows for the distributed recording and verification of transactions, new technologies are being marketed at a relentless pace. Some of these technologies have the potential to alter the way how businesses operate. For instance, maintaining asset records in a blockchain reduces the need for intermediaries in domains such as real estate or contracting. Process Mining algorithmically creates process maps from the digital log files of an organization, making previously unseen workflows visible, and in some cases replaces the need for business analysts to interview subject matter experts to develop a process map manually. Not every new technology is useful, and not every useful technology is new, but Business School students should be exposed to emerging technologies and learn how to assess their utility.

Some universities have specific courses on emerging technologies, which are receptacles for varying content, depending on which technologies are "hot" at the current time. Other universities have developed courses on specific emerging technologies and their application, for example, MIT's "Blockchain and Money" course.[24]

### 2.1.5. Theme 5: Managing Digital Organizations

Big Data and Artificial Intelligence give birth to new forms of organizing, as traditional industries face startups that can achieve scale with a fraction of the traditional labor force, as new labor markets emerge through gig-economy businesses such as vacation rentals and rideshare operators, and as digital native workers seek to participate from remote locations in virtual enterprises. These trends lead to new challenges for managers and employees alike, as traditional career pathways are changing, new skill demands require continual learning beyond college, and organizational cultures are increasingly influenced by online interactions rather than in-person events.

**Managing Digital Organizations is a relatively new topic in curricula; ethics and cybersecurity are two important themes in this area.**

The themes of Ethics and Cybersecurity are a cross-cutting concern that we found scarcely represented in most university curricula. Topics such as the ethics of hyper-personalization, the fairness of algorithms, the corporate responsibility for personally identifiable information (PII), and the monetization of derivative data by the likes of social media platforms (also termed surveillance capitalism) are discussed by regulatory bodies and policy-makers, but we found few places where these topics are embedded in the management curriculum.

Some examples of courses that focus on the management of digital themes can be found in MBA threads that were historically grouped in the field of "Technology Management". For example, Northwestern's course "Technology for Analytics: What a CMO Needs to Know"[25] focuses on the management of a data analytics function rather than the operational tasks of analyzing data. INSEAD is offering "AI strategy for Startups and C-Suites" as an elective course in their MBA curriculum.[26]

24. https://ocw.mit.edu/courses/sloan-school-of-management/15-s12-blockchain-and-money-fall-2018/
25. https://www4.kellogg.northwestern.edu/CoursePlanning/CourseCatalog/CourseCatalogScreen?coursename=MKTG-930-5&_ga=2.41725602.1426383894.1642116674-1594950848.1642116674
26. https://www.insead.edu/master-programmes/mba/academics/elective-courses/Marketing

## 2.2. Strategic vs. Tactical Digital Topics

When analyzing Digital Topics in the management curriculum, we can distinguish between strategic and tactical topics. While strategic topics deal with the value that organizations provide (the "what"), tactical topics deal with the mechanisms of value delivery (the "how").

The Digital Era does not change the fundamental strategic drivers of business:

- Organizations create a value proposition by developing products or services
- Organizations articulate their value proposition
- Organizations transact value by selling and providing products and services

In our analysis, we found few examples of programs that address the digital era at the strategy level. Most surveyed programs that had digital elements used these elements to teach specific tools and methods within the context of a particular application area. For instance, in Marketing, we saw evidence of Marketing Analytics courses that specifically focus on the data generated by online advertising platforms, and in the Finance curriculum, we saw courses on Algorithmic Trading, while courses on managing digital organizations were scarce. This may be explained by the easy availability of digital tools that instructors can integrate into their respective courses, but the relative scarcity of case studies and teaching materials that address larger strategic questions (such as the management of digital nomads or the use of hyper-automation to create competitive advantage). Focusing exclusively on tactical topics creates the risk of technology churn and the need for highly specialized faculty preparation.

## 2.3. Meta-skills

Meta-skills are the abilities of an individual that go beyond specific disciplinary or technical skills. For instance, the ability to communicate effectively in the workplace, the ability to think critically, the ability to lead with empathy, and mental agility are meta-skills that are not tied to any specific discipline. The Future of Work Task Force specifically identified the following meta-skills that students would benefit from having when entering the workforce:

- **Effective Communication:** Business School graduates increasingly have to articulate how the capabilities of new technology can be used to advance an organization's mission and how their use adds to the organization's value proposition. They need to be able to explain in simple terms how the constantly shifting technology landscape affects their and their colleagues' work.
- **Leadership:** The Digital Era causes changes in how and where work is done, how organizations are structured, and how individuals progress through an organization's ranks. Business School graduates need to be able to outline a clear vision of what their organization should look like and how the current organization can evolve to this future state.

- **Critical Thinking & Innovation:** As the digital era brings about new technologies and business models, Business School graduates need to be able to assess how these technologies and models differ from the current state of the art, how they might be leveraged to address current business issues, and how an organization might change in response. Whether it is the application of blockchain technology to a domain such as real estate, the prospect of a completely distributed workforce, or the scaling effects exhibited by platform businesses, Business School graduates need to be able to ask critical questions about these phenomena and envision how they might apply to their current organization.

- **Agile Mindset:** The Digital Era brings a high velocity of change to organizations. Tried and true business models are being disrupted by startups that do not carry technology debt, and Business School graduates should be able to adapt, respond, and innovate to these disruptions.

- **Empathy and Intercultural Skills:** An increasingly distributed workforce brings with it collaborations that would have been difficult to implement 20 years ago. It is not unusual for a worker in Europe to start their day with meetings that involve colleagues in Asia and end their day with meetings that involve co-workers in North America. The ability to bridge cultural gaps is of increasing importance in these interactions, as is the ability to manage teams that rarely, if ever, meet face to face. Organizational cultures that were built around geographic proximity and traditional shared values are being challenged by the influx of new workers that have different backgrounds and customs. Business School graduates need to be able to navigate these new waters.

- **Ethical Behavior:** The Digital Era brings about an increase in transparency because electronic communications are recorded for posterity and can be evaluated through technological means (e.g., sentiment analysis of phone calls, screening of emails for data leaks). Business School graduates need to be aware that anything they say, do, and write can surface and be scrutinized, often years after the fact. Adherence to high ethical standards is an important skill that Business School graduates should possess.

- **Appreciation for Privacy and Cybersecurity:** The digitization of organizational structures and processes introduces new risks, from cybercrime in the form of ransomware attacks to the reputational risk caused by the leakage of private information. Business School graduates need to appreciate the varying attitudes to privacy around the world and the operational and reputational risks organizations face based on their digital footprint.

**The challenges and opportunities of the digital era have triggered the creation of many specialty Master's programs, such as Supply Chain Analytics, Consumer Analytics, and so on. Some of these offerings are done in combination between the business school and a science department (e.g., CS or Math).**

## 2.4. Curricular Observations

Universities have responded to the emergence of digital topics in different ways, from updates to the content of existing courses to the development of entirely new degrees. The following section highlights some of these developments.

### New Degree Programs

Many Business Schools have responded to the increasing demand for analytics skills by launching specialty Master's programs under the moniker of Business Intelligence, Business Analytics, Data Analytics, and similar labels. Some of these programs have been in place for over a decade and have undergone several curriculum revisions and

refinements.[27] Many of these programs have taken on Statistics courses that originated in the Operations Management domain and added courses on Database Management and Modeling that were contributed by Information Systems departments.

The next stage of program evolution added data visualization courses and the domain-specific application of analytics techniques (e.g., Supply Chain Analytics and Marketing Analytics). Business Analytics programs compete with more specialized offerings in Data Science and Machine Learning, but these are often located outside of Business Schools in Engineering and Computer Science or sometimes in Math departments.

In addition to stand-alone Analytics degrees, a number of universities have begun to offer specialty Master's degrees that combine Analytics with a domain-specific offering. For example, Leeds University offers an MSc in Data Analytics and Human Resource Management,[28] American University a Masters in Marketing Analytics,[29] Rutgers University an MS in Digital Marketing,[30] or a Certificate in Audit Analytics[31], and many more.

Analytics is not the only area where new degrees are influenced by the emergence of digital technologies. Several universities have launched Master's Degrees in Digital Forensics,[32] focusing on the use of investigative techniques for digital devices and digital-based evidence. This is an example of a new credential for an occupation that is the direct result of the prevalence of digital technology, which has given rise to cybersecurity and cybercrime considerations.

In the area of the traditional MBA, several Business Schools have either launched STEM-oriented MBA programs or combined the MBA degree with a specialized Master's degree to add digital skills to the more established MBA content. Examples of the former are the Analytics MBA at Stevens Institute of Technology[33] or the Tech MBA from New York University.[34] Examples of the latter are the MBAi[35] from Northwestern's Kellogg School of Management jointly with their McCormick School of Engineering, Harvard's dual-degree MBA and MS in Engineering,[36] aiming at aspiring entrepreneurs, Stanford's dual MBA/MS degrees with select Engineering departments,[37] or Boston University's combined MBA and MS in Digital Technology.[38]

**STEM-oriented MBAs have grown, as have dual degree programs with Engineering disciplines.**

27. For instance, North Carolina State University's Master of Science in Analytics was launched in 2007 (https://analytics.ncsu.edu/), while Stevens Institute of Technology's Master of Science in Business Intelligence and Analytics was launched in 2012 (https://www.stevens.edu/bia).
28. https://courses.leeds.ac.uk/i693/data-analytics-and-human-resource-management-msc
29. https://www.american.edu/kogod/graduate/analytics/marketing-analytics-online.cfm
30. https://www.business.rutgers.edu/masters-digital-marketing
31. https://www.business.rutgers.edu/admissions/audit-analytics
32. https://catalog.gmu.edu/colleges-schools/engineering/electrical-computer/digital-forensics-ms/ and https://www.jjay.cuny.edu/master-science-digital-forensics-and-cybersecurity
33. https://www.stevens.edu/school-business/masters-programs/mba/analytics-mba
34. https://www.stern.nyu.edu/programs-admissions/tech-mba
35. https://www.kellogg.northwestern.edu/programs/full-time-mba/mbai-program.aspx
36. https://www.hbs.edu/mba/academic-experience/joint-degree-programs/Pages/ms-mba-engineering-sciences.aspx
37. https://www.gsb.stanford.edu/programs/mba/academic-experience/joint-dual-degrees
38. https://www.bu.edu/questrom/degree-programs/mba-ms-in-digital-technology/

**New Majors and Accelerated Masters Options at the Undergraduate Level**

At the undergraduate level, Business Schools have added new Majors and Minors in response to themes of the Digital Era. Some of these new offerings are graduate degrees that are now offered at the undergraduate level (for example, the Bachelor's in Quantitative Finance at Stevens Institute of Technology is an undergraduate program that contains elements of the Masters in Financial Engineering offered by many universities), but some are completely new offerings, such as the BSc in Management and Digital Innovation offered by the University of London.[39] Oher universities have added an accelerated Master's program option (often called 4+1) with a complementary Master's to their undergraduate degree offerings. In North America specifically, undergraduate degrees in Accounting are often offered in combination with graduate degrees in Accounting to cover the 150 hours of instruction required to qualify for the CPA certification exam. The Master's option provides room in the curriculum to add more specialized digital topics. An example is the combination of Accounting and Analytics degrees at St Mary's University.[40]

**New Courses**

We found many examples of Business Schools that have renamed courses, concentrations, and degrees to reflect digital themes that have been added to established courses and curricula. However, there are also examples of new course offerings that address digital era themes from the ground up. An example of this is the Harvard Business School course "Digital Innovation & Transformation."[41] In some cases, sequences of analytics courses are put together to create a concentration or certificate, e.g., Northwestern Kellogg is offering within the MBA a "Data Analytics Pathway."[42]

**Curricular Redesign**

Some Universities have added digital topics by substituting courses in established degrees. For instance, several universities in the Information Systems domain task force reported that the traditional strategy course in their MBA degree had been replaced by a course in IT strategy.

39. https://london.ac.uk/courses/management-and-digital-innovation
40. https://www.stmarytx.edu/academics/programs/accounting-data-analytics/
41. https://www.hbs.edu/coursecatalog/2134.html
42. https://www.kellogg.northwestern.edu/programs/full-time-mba/academics/majors-pathways/data-analytics-pathway.aspx

# 3. Disciplinary Findings

In the following section, we highlight some of the insights generated by the domain-specific task forces of the MaCuDE project. Each of these task forces has produced an individual report of their findings, and readers wishing a more in-depth discussion of the findings outlined here are referred to these reports, which can be accessed on the MaCuDE website.

### 3.1.1. Marketing

The Marketing Domain Task Force, led by Prof. Neal Roese (Kellogg School of Management, Northwestern University), identified three content buckets that exist in various marketing programs: Digital Marketing Tools; Marketing Analytics; and Communications, Brandin, and CRM.

**Marketing is one of the most developed disciplines in terms of digital maturity. Plenty of new programs or courses are available, specializing in:**

- **Digital marketing tools**
- **Marketing Analytics**
- **Communications, Branding & CRM**

- **Digital Marketing Tools:** Tactical tools for advertising and selling represent the most frequently observed content across marketing courss, and were evenly prominent across the surveyed programs in Asia, Europe, and North America. The most frequent topic in this space is the use of social media, followed by search engine optimization, mobile marketing, and influencer marketing. Examples of courses in this bucket are "New Media in Marketing"[43] or "Social Media and Mobile Technologies"[44] (both from NYU/Stern), "Media Technologies" (Macquarie University), or "Entrepreneurial Tool for Digital Marketing". Some schools have developed specific Digital Marketing lab courses, e.g., the "Digital Marketing Lab" (Chicago/Booth) or "Foundations of MarTech" (Santa Clara/Levy).

- **Marketing Analytics:** The use of statistical methods to make informed business decisions represents the second area of digital marketing content observed by the task force. Specifically, the use of data-driven approaches for pricing and messaging decisions is prominent across many marketing programs, with courses such as "Marketing Analytics" (Penn/Wharton[45]); "Retail Analytics and Pricing"[46] (Northwestern/Kellogg), "Consumer Analytics and AI"[47] (Northwestern/Kellogg), or "Digital and Algorithmic Marketing"[48] (Chicago/Booth and Stanford). A number of schools, e.g., Wharton or Kellogg, are offering a certificate program on Customer Analytics.[49] [50] It is interesting to note that Facebook/Meta is offering a "Marketing Analytics Professional Certificate Program"[51] with Coursera. Courses in this space often contain a programming component (either R or Python).

43. https://web-docs.stern.nyu.edu/marketing/syllabi/syllabiF18/MKTG-GB.2173_NewMedia_Edis_F18.pdf
44. https://web-docs.stern.nyu.edu/marketing/syllabi/syllabiS18/MKTG-GB.2150.30_SocialMedia_Krentzman_S18.pdf
45. https://online.wharton.upenn.edu/marketing-analytics-data-tools-technique/
46. https://www4.kellogg.northwestern.edu/coursecatalogschedule/CourseDetail.aspx?CourseID=205517
47. https://www4.kellogg.northwestern.edu/coursecatalogschedule/CourseDetail.aspx?CourseID=206769
48. https://intranet.chicagobooth.edu/pub/coursesearch/CourseDetail?AcademicYear=2021&CourseNumber=37304&ProfessorIds=234143
49. https://online-execed.wharton.upenn.edu/marketing-analytics
50. https://kellogg-executive-education-online.emeritus.org/marketing-analytics
51. https://www.coursera.org/professional-certificates/facebook-marketing-analytics

- **Communications, Branding, and CRM:** Communications and branding have changed drastically in the digital era. Branding today is mostly done via digital platforms such as the web, mobile applications, or social media, with digital media content that includes website content, blogs, videos, e-mailers, etc., for the specific target group. There is also a need for integrating messages across platforms, channels, and media. These changes have given rise to a number of courses such as "Branding in the Digital Era"[52] (Stanford), "Advertising 3.0-Communications in the Digital Era" (NYU/Stern), "Integrated Marketing and Communications (e.g., Santa Clara/Leavy,[53] or Macquarie University[54]) and more. Similar changes have happened in the Customer Relationship Management (CRM) function, with new courses appearing in this area too.

Curricular developments in the marketing discipline include new tracks (for example, Digital Marketing specialization in the business undergraduate program at New York University) as well as specialized certificates, such as the undergraduate certificate in Marketing Analytics at the University of Missouri. Many schools possess separate marketing master's programs beyond their MBA program in which the bulk of digital content was covered.

While **ethics and privacy** are important topics in the context of customer analytics courses, the task force found that Schools in Europe tend to have more content relating to data privacy, but overall not many courses explicitly covered data privacy or legal issues. Still, some programs had specific courses designated solely to data privacy and legal issues. For example, EM Lyon offers "Responsible Artificial Intelligence" as part of their MSc in Digital Marketing & Data Science.[55] An example of a stand-alone ethics course is Rutgers University's "Digital Marketing Law, Policy and Ethics" course.[56]

### 3.1.2. Finance

Business Schools offer finance education at different levels, ranging from Finance majors and minors at the undergraduate level, through Finance tracks in MBA programs to more specialized Finance Master's programs. The Finance Domain Task Force, led by Profs Leila Guerra and Christopher Neill (Imperial College London), reviewed these offerings and found that digital content across these curricula falls into five categories that complement the common traditional subject areas of Corporate Finance and Investment Management:

**The Finance discipline has a high degree of digital maturity, as evidenced by many programs in Financial Engineering or Financial Analytics.**

- **Data Analytics and Machine Learning,** examining how the combination of large datasets and empirical techniques help companies make more efficient financial decisions. Examples of courses in this category are "Financial Data Science"[57] (Carnegie Mellon/ Tepper), "Advanced Analytics and Machine Learning in Finance" (MIT/Sloan), or "Machine Learning in Finance"[58] (Stevens Institute of Technology), "Financial Data Science"[59] (UC Berkeley/Haas).

52. https://explorecourses.stanford.edu/search?view=catalog&filter-coursestatus-Active=on&page=0&catalog=&q=MKTG+554%3A+Branding+in+the+Digital+Era&collapse=
53. https://www.scu.edu/business/graduate-degrees/student-services/academic/concentrations/marketing/
54. https://unitguides.mq.edu.au/unit_offerings/17871/unit_guide
55. https://masters.em-lyon.com/en/msc-in-digital-marketing-data-science/program
56. https://www.business.rutgers.edu/masters-digital-marketing/curriculum
57. https://www.cmu.edu/mscf/academics/curriculum/46921-financial-data-science-i.html
58. https://www.stevens.edu/school-business/masters-programs/financial-analytics/curriculum-overview
59. https://mfe.haas.berkeley.edu/academics/curriculum

- **Programming,** developing the students' coding skills, as programming has become an essential skill in the sector and many companies look for these skills for their graduate roles (mostly Python and R). Examples are Applications of R in Finance"[60] (imperial College London). Programming is not always covered as a separate or introductory course. Some programs expect a level of coding skill as a prerequisite

- **Algorithms and Algorithmic Trading,** with courses looking closely at analytical techniques and quantitative methods relevant for algorithmic trading strategies. Examples of courses offered are: "Algorithmic Trading"[61] (Baruch) and "Algorithmic Trading Strategies"[62] (Stevens).

- **Blockchain and Crypto Currencies,** with modules covering the core aspects of the technology with reference to Bitcoin and other crypto assets or looking at the impact and disruption of Blockchain and Artificial Intelligence on Businesses. Examples: "Blockchain in Finance"[63] (Baruch).

- **Financial Technology,** with one or more courses on multiple new technologies that are getting introduced into financial services, and that affect practically every function of financial services. Financial Technology can either be an applied in-depth program or a course offering an overview of the FinTech sector. Example of the former is NYU's MBA specialization in Fintech[64] and of the latter are London Business School's course "Fintech"[65] or the University of Michigan Ross' course "Fintech."[66] The latter is increasingly more common in MBA programs.

These categories compliment the common traditional subject areas of Corporate Finance and Investment Management.

Curricular developments in the finance discipline include new specialized undergraduate finance programs (for example, Quantitative Finance at Stevens), new specialized masters programs (e.g., Financial Engineering at many schools, including Baruch, UC Berkeley, Stevens, and others), specializations in the MBA program, as well as many specialized certificate programs. Some Schools have developed new programs to address digital skills in Financial Technology and Financial Engineering. These new programs tailor to digital skill development in their core content with further specialization in portfolios of digital electives. There is a stronger focus on digital skills within Finance in MS Finance programs than UG or MBA programs. There is more focus on Ethics in MBA programs than specialist UG and MS programs in Finance.

**Courses in Data Analytics, Machine Learning, Programming, Algorithmic Trading, Blockchain, Crypto, Decentralized Finance, and Fintech all reflect the ongoing changes in the financial sector.**

60. https://www.imperial.ac.uk/business-school/programmes/msc-finance/programme/core-modules/#foundations-in-finance-application-of-r-for-finance-
61. https://mfe.baruch.cuny.edu/curriculum/
62. https://www.stevens.edu/school-business/graduate-certificates/algorithmic-trading-strategies
63. https://mfe.baruch.cuny.edu/curriculum/
64. https://www.stern.nyu.edu/programs-admissions/full-time-mba/academics/specializations/fintech
65. https://www.london.edu/masters-degrees/masters-in-financial-analysis/programme-content/electives
66. https://michiganross.umich.edu/courses/fintech-blockchain-cryptocurrencies-and-other-technology-innovations-1156

### 3.1.3. Accounting

The Accounting function has been deeply affected by Analytics and Big Data. Much of the work that used to be done 20 years ago by first- or second-year associates is now automated or outsourced. At the same time, due to the professional certifications typically associated with the Accounting profession, the coursework in accounting programs from around the world have evolved to provide students with the education required by examining bodies. There is an expectation that the undergraduate degree will provide students with what is needed to be successful in the CA/CPA examinations. As such, there is substantially less variation in accounting programs than one might otherwise expect.

**Accounting programs frequently include digital topics such as the use of data integration tools, data visualization, textual analysis, and modeling in Excel.**

The Accounting Task Force, led by Profs Nicole Jenkins (University of Virginia) and Rose Layton (University of Southern California) did a thorough review of the accounting curricula. A main conclusion from the the task force's work is that digital content in accounting is primarily comprised of managing and manipulating large data sets, applying analytics tools to answer questions and tell a story, and understanding automation of accounting functions. More specifically, the task force found that the key digital themes covered in undergraduate accounting curricula are:

- **Accounting and Business Analytics,** with courses that tend to focus on acquiring the skills needed to examine data and tell a compelling story within a specific business or accounting context.
- **Data management and manipulation,** with courses that teach data science type skills rather than analytics.
- **Modeling classes,** that focus primarily on decision modeling, visualization and predictive modeling, and financial modeling.
- **Software/programming coursework,** that covers statistical packages, programming languages (e.g. Python) and programs (mobile applications) that are frequently used within the area of accounting.

The majority of undergraduate programs have embedded digital skill acquisition into multiple courses while most of the rest provide this instruction in a stand-alone class. When embedded within existing courses, the content is most frequently included in Information Systems and Auditing courses. However, this content is also distributed across tax, advanced accounting and managerial classes. The products and topics that are most frequently included are Alteryx, data visualization software, textual analysis and modeling in excel.

At the graduate level, digital content in the form of stand-alone coursework was found in the majority of the schools in the sample. The topical focus of those courses varies with the most common as a requirement or an elective being in the area of accounting and business analytics. Courses on data management, modeling and programming tended to be part of degree programs that had been designed with a focus on analytics.

Within the graduate curriculum, digital content is most frequently embedded in Accounting Information Systems followed by Auditing and then Managerial/Cost Accounting and Advanced Accounting. Again, the most common software used in the undergraduate course work are Excel and Tableau Alteryx was the sole additional software that is used in graduate programs.

### 3.1.4. Management and Human Resource Management

The MaCuDE Management Domain Task Force, led by Prof. Tom Begley (Rensselaer Polytechnic Institute) identified two main areas of digital content in the general management curriculum: People Analytics and the Management of Digital Transformation. The first one deals with HRM, the second with management. Additional digital content is represented in four additional ones Human Capital, Managing Technology, Social Networks, and the Ethics of People Analytics/Digital Transformation.

**Management programs are offering courses in People Analytics and focus on the Management of Digital Transformation efforts.**

- **People Analytics** represents the application of business analytics techniques to workforce data. People Analytics courses have begun to appear across the undergraduate, Master's, and MBA levels. For example, at the undergraduate level, Purdue University hosts the HR Analytics Interactive Lab,[67] and McGill University offers an undergraduate course on "People Analytics"[68]. At the Master's level, schools like Stanford University,[69] City University of Hong Kong,[70] or National University of Singapore offer the simply-titled "People Analytics" course. Variations include "Talent Development and Analytics"[71] (Free University of Amsterdam), "Talent Analytics: Data and Tools"[72] (Higher School of Economics), "HRM Technology, Analytics, and Digital Innovation"[73] (University College Dublin), "Strategic Human Resource Metrics & Analysis"[74] (Cornell University), "Data Analytics for HRM" (Leeds Beckett[75]) or "HR Analytics and Internal Auditing"[76] (Lisbon's ISCTE). Many MBA programs also offer a certificate program, e.g., Wharton.[77] It is interesting to note that elvtr.com is also offering a course on "Human Resources Analytics"[78].

- **Managing Digital Transformation** addresses the impact of digitalization on work and the workplace. This topic is also addressed by the Strategy, Innovation and Entrepreneurship section 3.1.6. Because of its broader view, few undergraduate programs offer targeted programs or courses, with

67. https://polytechnic.purdue.edu/facilities/purdue-hr-analytics-interactive-learning-lab
68. https://www.mcgill.ca/study/2021-2022/courses/orgb-330
69. https://explorecourses.stanford.edu/search?q=HRMGT%20203&academicYear=20182019
70. https://www.cityu.edu.hk/catalogue/pg/202122/course/MGT6310.htm
71. https://studiegids.vu.nl/en/Master/2021-2022/business-administration/E_BA_TDA
72. https://www.hse.ru/en/edu/courses/395884911
73. https://hub.ucd.ie/usis/!W_HU_MENU.P_PUBLISH?p_tag=SMOD&MAJR=B265&MODULE=HRM40880
74. https://classes.cornell.edu/browse/roster/SP19/class/ILRHR/5660
75. https://courses.leeds.ac.uk/i693/data-analytics-and-human-resource-management-msc
76. https://www.iscte-iul.pt/course/140/master-msc-in-human-resources-management-and-organizational-consulting/studyplan
77. https://online-execed.wharton.upenn.edu/hr-management/
78. https://elvtr.com/course/human-resources-analytics

the few including the "Business and Technology major"[79] at Stevens Institute of Technology, the "Business + Tech Hub"[80] at the University of Michigan or the "Management Consulting track of the Management major"[81] at Lehigh University. Other schools offer dual or joint undergraduate degrees covering aspects of digital transformation, e.g., Lehigh University offers a joint BS in Computer Science and Business,[82] while Yale University offers a joint degree BS in Computer Science and Economics[83] as well as dual degrees e.g., Applied Math[84] and Economics.[85] The topic of digital transformation receives the most coverage among Master's programs. Many schools offer executive programs, e.g., Digital Transformation (ESSEC[86]). Generally, most of the courses include Digital Transformation in their titles (e.g., Copenhagen, ESADE, Indian Institute of Management – Calcutta), with some pursuing variations like Theories of Digital Business (Amsterdam), Modern Ways of Working in the Digital Age (ESCP), and E-HR (National Taiwan University), Digital Transformation (Stanford[87]). The list of MBA programs with digital transformation courses is modest, exemplified by Dartmouth's Digital Transformation[88] (together with Coursera) or Digital Change Strategies, Sasin's Digital Transformation: Emerging Technologies and Strategies, and Hong Kong UST's Digital Leadership and Teamwork.

- **Human Capital.** Human capital, a concept used by companies as a way to evaluate how prepared their employees are to tackle the competitive challenges they face, is related to people analytics, as a way to gain the insights that will allow a company to increase its human capital. Courses or programs in human capital have started appearing. Some examples include "Human Capital Management"[89] (IE), "Leveraging Human Capital and Performance"[90] (Sussex), and "Introduction to Managing Human Capital"[91] (Michigan). MBA courses on the topic are offered mainly by highly respected schools such as Harvard (Managing Human Capital), Darden (Human Capital Consulting), and Chicago (Leadership Capital).

- **Managing Technology.** A fourth area positions digitalization as the dominant current form of technology. Examples of undergraduate courses are "Technology and Organization"[92] (Nottingham University) and "Organizing in the Digital Age: Power, Technology, and Society"[93] (University of Lancaster). Examples of Master's courses include "Global and Distributed Teams"[94] (Carnegie Mellon), "Managing AI"[95] (Stevens), or "Business Implications of Emerging Technologies"[96] (RPI).

79. https://www.stevens.edu/school-business/undergraduate-programs/business-technology
80. https://michiganross.umich.edu/about/business-tech
81. https://business.lehigh.edu/departments/management/undergraduate-management-programs/undergraduate-management-major
82. https://business.lehigh.edu/undergraduate/degree-programs/bs-computer-science-and-business
83. http://catalog.yale.edu/ycps/subjects-of-instruction/computerscienceandeconomics/
84. http://catalog.yale.edu/ycps/subjects-of-instruction/applied-mathematics/
85. http://catalog.yale.edu/ycps/subjects-of-instruction/economics/
86. https://digitalcampus.essec.edu/executive-master-digital-transformation/
87. https://online.stanford.edu/professional-education/digital-transformation
88. https://www.coursera.org/certificates/digital-transformation-dartmouth
89. https://www.ie.edu/business-school/programs/masters/master-in-talent-development-human-resources/
90. https://www.sussex.ac.uk/business-school/internal/departments/accounting-finance/ugcourses/2019/NN144U/81935
91. https://michiganross.umich.edu/courses/introduction-managing-human-capital-10142
92. https://www.studocu.com/en-gb/document/university-of-nottingham/technology-organization/technology-and-organisation-revision-guide/12444063
93. https://www.lancaster.ac.uk/study/international-students/visiting-students/study-abroad-modules/013926#OWT.326
94. https://www.cmu.edu/tepper/programs/courses/45844.html
95. https://www.stevens.edu/school-business/graduate-certificates/management-ai
96. http://catalog.rpi.edu/preview_course_nopop.php?catoid=5&coid=8819

- **Social Networks.** Several courses have been developed to analyze today's complex social networks. An interesting example is the undergraduate course "Digital Society: Your Place in a Networked World"[97] (University of Manchester), which examines the connectedness of digital life, the relationship between the individual and the state, the smart cities of the future (and now), ethics of the online world and the impact of digital and mobile technology on business and marketing. The course has a strong employability focus, as it aims for students to develop transferable skills relevant to life beyond their studies, including real experience of blogging, critical thinking and reflection, peer learning, collaborative tools, researching and curating content, maintaining an online profile and presentation skills. Other interesting exmples of courses are Master's "Social Network Analysis"[98] (offered by UC Davis and Coursera), and MBA's "Managing Social Networks in Organizations"[99] (Stanford).

- **Ethics of People Analytics/Ethics of Digital Transformation.** Finally, we include the topic of ethics not because it has a strong presence – it does not – but rather because we see a strong need for ethics courses in both the People Analytics and Digital Transformation domains. An interesting course is the undergraduate course by Cornell's School of Industrial and Labor Relations on the "Ethics and Policy in Data Science"[100]. Another is Dartmouth's "Ethics and Social responsibility requirement"[101], as well as a rather large number of elective courses[102] or Dartmouth's Center for Business, Government and Society[103].

### 3.1.5. Information Systems

**Information Systems has traditionally been a home for many of the emerging digital themes.**

The Information Systems Domain Task Force, led by Kalle Lyytinen (Case Western Resrve University) collaborated with the Association of Information Systems' Curriculum Development Task Force to assess the state of digital topics in the IS curriculum. As Information Systems has traditionally been a home for many of the emerging digital themes, this task force could leverage a deeper set of data than many others, beginning with the global repository of Information Systems courses (www.eduglopedia.org). The Association for Information Systems offers a reference curriculum that has been regularly revised since 1997, and most recently published in 2020 in combination with the Association of Computing Machinery.[104] It should be noted that the most recent curriculum report covers many computing disciplines, including Information Systems, Computer Science, Cybersecurity, Data Science, and others, highlighting the high degree of connectivity between these areas. What sets Information Systems apart from other computing disciplines is the degree to which it is embedded in and organizational context (typically business), and the extent to which it emphasizes the application of technology to organization-specific problems.

97. https://www.college.manchester.ac.uk/units/?year=2021&semester=2&course=400
98. https://www.coursera.org/learn/social-network-analysis
99. https://explorecourses.stanford.edu/search?view=catalog&filter-coursestatus-Active=on&page=0&catalog=&q=OB+522%3A+Managing+Social+Networks+in+Organizations&collapse=
100. https://courses.cornell.edu/preview_course_nopop.php?catoid=31&coid=501730
101. https://www.tuck.dartmouth.edu/mba/academic-experience/required-curriculum/ethics-and-social-responsibility
102. https://www.tuck.dartmouth.edu/mba/academic-experience/elective-curriculum/elective-courses
103. https://cbgs.tuck.dartmouth.edu/center-activity/courses-electives
104. https://www.acm.org/binaries/content/assets/education/curricula-recommendations/cc2020.pdf

Information System graduates are often positioned at the interface between more functional business disciplines (for instance, Marketing or Finance), and more technical computing disciplines (for instance, Software Engineering or Computer Science). As translators between disciplines they must be able to understand the capabilities of new technology, assess its impact on an organization, its relationship to the established tools, processes and structures, and develop plans for the deployment of such technology in an organization. They must also understand the utility of various technologies in the context of business applications, and be conversant in how strategic and operational changes of an organization may alter its need for technology solutions. As such, Information System students focus on Digital Transformation, i.e., the process through which organizations change using computing capabilities.[105]

The Information Systems Task Force found that many of the undergraduate programs they reviewed followed the curriculum model of the 2010 Association for Information Systems Model Curriculum, which includes core courses on the Foundations of Information Systems, Enterprise Architecture, IT Strategy, Data and Information Management, Systems Analysis and Design, IT Infrastructure, and IT Project Management, combined with a variety of elective courses. New topics that were not included in the model curriculum are courses around Cybersecurity and Big Data Analytics. At the graduate level, Analytics courses are becoming a core component of the Information Systems curriculum, while at the undergraduate level they were mostly identified as elective courses. Courses covering Artificial Intelligence or Machine Learning were absent at the undergraduate level. The task force found that these topics are introduced at an overview level as part of more general courses (e.g., Management Information Systems).

**Information System students focus on Digital Transformation, i.e., the process through which organizations change using computing capabilities.**

Specific Digital Era topics that the task force identified across Information Systems curricula were:

- Big Data/Data Science: Nearly all surveyed undergraduate and graduate curricula in Information Systems contained courses on Analytics and Data Science topics.
- Automation and Algorithms: The majority of undergraduate and graduate curricula in Information Systems surveyed contained one or more courses in this space.
- AI and Machine Learning: While a significant number of graduate programs offered courses in Artificial Intelligence and Machine Learning, there was a gap at the undergraduate level, where only half of the surveyed universities offered a course on these topics.
- Blockchain Technology: The emerging topic of Blockchain and distributed ledgers can be found in an increasing number of Information Systems programs, both at the graduate and undergraduate level.
- Design Thinking: Even though Information Systems professionals are often tasked with the design of Digital Transformation initiatives at the strategic, tactical, or operational level, the topic of design thinking has surprisingly little coverage in the surveyed Information Systems curricula.

105. See ACM, Computing Curricula 2020, p. 30.

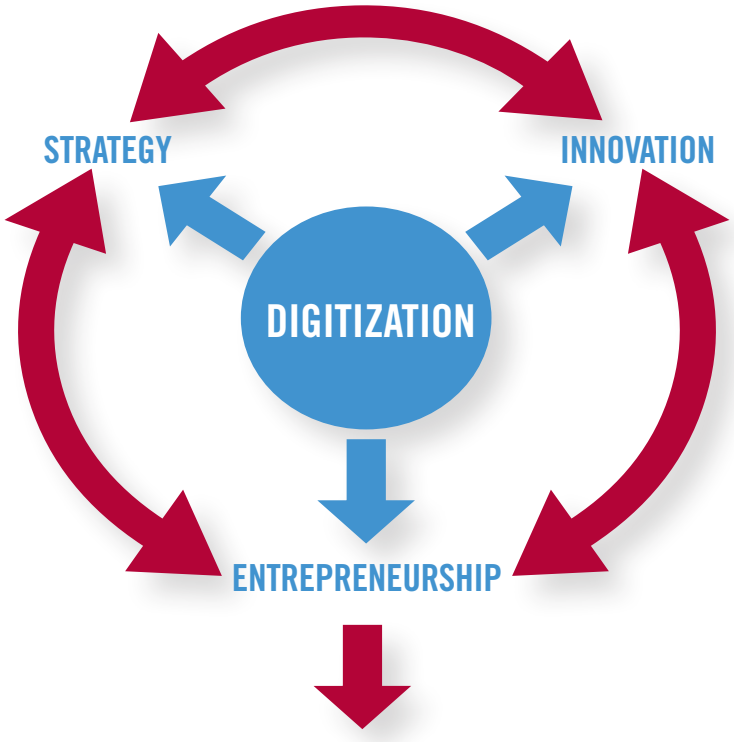
One topic of regular discussion in the Information Systems Task Force was the delineation between Information Systems and Analytics curricula, as there exists content overlap with regard to the management of data and other foundational technical topics covered in both Information Systems and Analytics, as well as between Information Systems and Computer Science when topics such as Artificial Intelligence and Machine Learning are concerned. The Association for Computing Machinery (ACM) specifically calls out areas where computing programs intersect with other domains, and calls these either "Computing + X" or "X + Computing" (for instance medical informatics, bioinformatics, or FinTech).

### 3.1.6. Strategy, Innovation and Entrepreneurship

Digital technologies and analytics have induced radical changes in the market and in the strategy of the modern businesses. They have also created new approaches to innovation and have created many opportunities for entrepreneurship. The Strategy-Innovation-Entrepreneurship (SIE) task force, led by Prof. PD Jose (IIM Bangalore), did a thorough study of the curricular changes that have taken place to address these changes. The courses that have been developed or restructured can be integrated into the following general scheme:

- Programs connecting digitization to one of the three realms:
  - Strategy
  - Innovation
  - Entrepreneurship

- Interdisciplinary programs on the interactions between the three elements above in a digitization framework such as the one below.



- **Strategy in the Digital Age.** To address the digital reality, Strategy courses in many schools have been redesigned, whereas in others, a new course on Digital Strategy or other courses or programs on **Digital Transformation** have been developed, where they stress on digital technologies as a dominant emerging force in influencing businesses. Many of the programs on Digital Transformation are offered in the executive education space. The content of these programs varies, but the overriding idea is to provide leaders of traditional companies as well as entrepreneurs a hands-on tour of the issues and the technologies involved to drive change in their organization in the digital era. An example of such an executive program is Columbia University's online executive program "Digital Strategies for Business,"[106] which covers topics such as an overview of the domains of digital transformation, understanding digital customer behavior and customer networks, platform business models, coopetition, disintermediation and asymmetric competitors, building data as a strategic asset, innovation through experimentation, moving from lean startup to enterprise scale innovation, and mastering disruptive business models. On the other hand, MIT/Sloan's program "Digital Transformation: From AI and IoT to Cloud, Blockchain, and Cybersecurity"[107] focuses more on technologies – such as Blockchain, AI and the Future of work, Internet of Things, Cloud and Cybersecurity – and what opportunities these technologies offer for an organization. A different approach is taken by Grenoble's EM Advanced Master Program on Digital Strategy,[108] where 2-3 days are spent on a wide variety of topics, including Web Marketing Strategy, Digital Marketing Techniques, Digital Project Management, Mobile Marketing and IoT, Content Creation, Digital transformation, Geo-Strategy, User Experience, Digital Technologies & Innovation, Legal Issues. Because of its importance in the digital era, some schools have established centers for Digital Transformation. One example is the Center for Digital Transformation[109] at Irvine's Paul Merage School of Business. The center does research on five focus areas – Economics of the Digital World, Digital Services Delivery, Digital Business Models, Big Data and Analysis, and Emerging Digital Trends and Applications – while it also runs educational programs, conferences, and roundtables on topics of digital transformation and digital leadership. Another example is Dartmouth's Center on Digital Strategies[110] focusing on five areas of expertise – Enterprise Transformation, Technology and Innovation, Digital Business Models, Trust/ Security/ Privacy, and Digital Society – and providing a large range of learning opportunities including support for the MBA program.

**To address the digital reality, strategy courses in many schools have been redesigned, whereas in others, a new course on Digital Strategy or other courses or programs on Digital Transformation have been developed.**

- **Digitization and Innovation.** In this part, we can distinguish two different types of programs: First, those that at the core rely on the idea of digital thinking and its consequences in the design of the organization that, in the end, will generate innovations. Second, those other programs that focus on the emergence of new technologies that are connected in some way to digitization and that have an impact on firms' innovation policy. The interaction between digital thinking and digital technologies provides an overall view of the impact of digitization on innovation.

106. https://online1.gsb.columbia.edu/digital-strategies
107. https://mit-online.getsmarter.com/presentations/lp/mit-organizational-design-for-digital-transformation-online-short-course
108. https://en.grenoble-em.com/advanced-master-digital-strategy-management
109. https://merage.uci.edu/research-faculty/centers/digital-transformation/index.html
110. https://digitalstrategies.tuck.dartmouth.edu

- **Design/Digital Thinking.** There has been a growth of offerings in Design Thinking that are connected to digital thinking. Michigan Ross has developed a whole suite of activities to promote Design thinking and Innovation.[111] Boston University offers a course Organizing for Design and Innovation[112] which examines how managers and leaders can create the conditions for innovation at the individual, team and organizational levels and how those conditions differ for startup and mature organizations. The way to optimize these conditions is to adopt a digital thinking approach. Stevens offers a course on "Human Centered Design Thinking"[113] which deals with the theory and methods associated with design thinking, as a problem-solving protocol that spurs innovation and solves complex problems and which involves a unique form of inquiry that goes well beyond product and service design. Harvard offers an executive education course on "Design Thinking and Innovation"[114].

  **There has been a growth of offerings in Design Thinking that are connected to digital thinking.**

- **Emerging Digital Technologies**. Given the growth of digital technologies, and the opportunities these present for improving efficiency and effectiveness, and also for developing innovative business models, a number of schools are offering courses providing an overview of emerging technologies leading to innovation. An example is the course offered by Michigan Ross "Tech Trends and Value Chain Innovations,"[115] which provides MBA students with a foundational understanding of some of core technologies fueling the digital transformation and a deeper appreciation of the nature of the transformation taking place. Another example in this category is UC Berkeley's executive program "Future of Technology: Trends, Strategies and Innovation Opportunities,"[116] which provides a framework for assessing key disruptive technology trends such as AI, IoT, Robotics, Quantum Computing, Cybersecurity, and Blockchain, and for creating a roadmap to implement innovation strategies.

- **Entrepreneurship and Digitization.** A number of courses are being offered for aspiring entrepreneurs in the new economy by using technology to create a sustainable new economy business model. Other courses focus on the commercialization of frontier technologies which aim to familiarize the student with both the technical aspects of developing technology, and the research and assessment activities that need to be conducted to turn a viable new technology into a marketable product. Other courses examine entrepreneurship on the mobile platform. For example, the course "Mobile Innovation Development"[117] offered at the University of Michigan Ross, helps students understand the unique requirements of mobile business to successfully design, develop, deploy and manage business innovations by taking them through the application (app) development process covering the full spectrum from identifying customer needs to prototyping/simulating a mobile innovation solution.

111. https://ross.campusgroups.com/designplusbusiness/design-thinking-and-innovation-at-michigan-ross/
112. https://www.bu.edu/academics/questrom/courses/qst-si-451/
113. https://www.stevens.edu/school-business/masters-programs/mba/analytics-mba/curriculum
114. https://online.hbs.edu/courses/design-thinking-innovation/
115. https://sites.google.com/umich.edu/rosstodept/to-electives/mba-electives#h.p_yJINI7QEEBAY
116. https://executive.berkeley.edu/programs/future-technology
117. https://umich.edu/rosstodept/to-electives/mba-electives#h.p_tLJf8UWtCHd6

- **Interactions between Strategy, Entrepreneurship & Innovation**

  - **Strategy for startups and high-tech companies.** Courses have been developed addressing strategy for startups and for high-tech companies, including companies in artificial intelligence, autonomous vehicles, cloud services, e-commerce, social networking, Blockchain and more. An example of such a course is Boston University's "Strategy for technology-based firms"[118] which covers technology lifecycles, the co-evolution of industries and technologies, strategies for commercialization of new technologies (appropriability, acquiring complementary assets and capabilities, managing technical teams, and impact of regulatory and other environmental factors on commercialization). Another example is a course offered by the Imperial College connecting new technologies (AI) with startups that are natural sources of innovation (AI startups & Innovation).[119]

  - **Ethics and Environmental Sustainability in the Digital Era.** Key elements that are less developed in the different curriculum covering the digitization phenomenon and its impact on different stakeholders are issues of Ethics and Environmental Sustainability. A good summary of the relevant questions in this realm can be found in the Wellcome Centre of Ethics and Humanities at the University of Oxford.[120] The emergence of Digital, artificial intelligence and data-driven technologies (DAID) not only has an impact on: (i) the creation of companies: (ii) the different strategies defined; and (iii) the types of innovation generated, but also on ethical and environmental sustainability aspects. Relevant questions to address in this realm are: How to balance the trade-offs between DAID technologies benefits and drawbacks connected to the facility these new technologies have brought for unethical behaviors (e.g., privacy issues); What are the better strategies to stimulate Responsible Innovation; How to stimulate in a democratic way those established firms to create new ventures that define strategies conforming to ethical and environmentally sustainable principles? In this line, Georgetown offers a course on Ethics in the Digital Era.[121] This course analyzes ethical issues that come out in a digital world. Important elements to consider are: core values of privacy, consent, fairness, and legitimacy.

**The emergence of digital, artificial intelligence and data-driven technologies not only has an impact on the creation of companies, the different strategies defined; and the types of innovation generated, but also on ethical and environmental sustainability aspects.**

As a **conclusion,** there is a wide set of courses that analyze the digitization phenomenon through its connection with firm's strategies, firms' innovation, and the creation of new firms. The overall picture, including the interaction between these different elements, allows providing the clues that students should know for achieving and maintaining a competitive advantage in these turbulent environments that have been shaken by the emergence of the digitization phenomenon.

118. https://www.bu.edu/academics/questrom/courses/qst-si-482/
119. https://imperial.esmelearning.com/pages/lp-imperial-ai-startups
120. https://www.weh.ox.ac.uk/research/digital-environmental-sustainability-ethics
121. https://myaccess.georgetown.edu/pls/bninbp/bwckctlg.p_disp_course_detail?cat_term_in=201810&subj_code_in=BADM&crse_numb_in=746

### 3.1.7. Analytics

The discipline of Analytics serves as one of the key areas of digital skill-building. Analytics degrees began to emerge as free-standing graduate programs in the late 2000s, and have increasingly influenced other disciplines. Programs such as North Carolina State University's Master of Science in Analytics and Stevens Institute of Technology's Master in Business Intelligence & Analytics represent pure analytic programs. A more recent trend are "X + Analytics" offerings, such as Marketing Analytics, Supply Chain Analytics, or Accounting Analytics, which are offered as certificates or minors in undergraduate programs. The Analytics/Operations Management task force, led by Prof. Ravi Subramanian (Georgia Tech), conducted a survey of undergraduate and graduate programs in Analytics, focusing on course content that reflects digital themes.

Statistics and Operations Research form the foundation for most Analytics programs, combined with courses on data management and data analysis. In terms of coverage for specific topics, undergraduate programs in Analytics tend to emphasize Decision Support Systems, Algorithms, and Ethics, while graduate programs showed a focus on Algorithms, Machine Learning, and more specialized topics.

**Many analytics programs teach hands-on technology.**

Many analytics programs teach hands-on technology. At both the undergraduate and graduate level, Excel and Tableau are the dominant platforms used, followed by R, Python, SPSS, and SAS.

An encouraging observation among the courses surveyed was the consideration of topics related to sustainability and ethics. Related topics discussed within the courses include ethical issues in analytics (e.g., data privacy and transparency of analytics models and algorithms), and the relationship between analytics and corporate social responsibility (economic, social, and environmental).

### 3.1.8. Cybersecurity and Ethics

The technological advances of the Digital Era introduce new risk factors for organizations, which range from network-based cyberattacks aimed at disrupting business (such as Distributed Denial-of-Service hacks) to economic threats, such as ransomware attacks. These topics are often addressed at a technical level in Computer Science and Cybersecurity programs, but their treatment as risk factors in Business Schools is considerably less evolved.

In addition to cybersecurity threats, digital business models introduce new ethical topics that Business School graduates should be aware of, such as the emergence of business models that are built on data integration and surveillance, the risks and benefits of hyper-personalized marketing efforts, and the organizational impact of data-driven management techniques (such as Bridgewater Associates management mantra of "radical transparency"). To date, Business Schools have incorporated these topics unevenly into their curricula.

**Business Schools have incorporated ethics and cybersecurity topics unevenly into their curricula.**

- At the undergraduate level, University of Pennsylvania, University of Virginia and University of Notre Dame offer individual courses on privacy and Cybersecurity, whereas at other schools these topics are mainly sub-topics in broader courses. Examples are “Ethics of Data Analytics” at University of Notre Dame, “Intro to Cybersecurity” at the University of Virginia, and “Big Data, Big Responsibilities: The Law and Ethics of Business Analytics” at the University of Pennsylvania.

- At the graduate level, Northwestern University and New York University offer courses on privacy and Cybersecurity, while most other universities handle these topics as modules in broader courses. Examples of the former are “Information Privacy” in Northwestern’s MBA program, and “Cybersecurity and Privacy” at New York University. Some universities offer Specialty Masters in Cybersecurity, for example the University of California, Berkeley, and Georgia Institute of Technology.

# 4. Development Pathways

Business Schools that are looking to incorporate Digital Era themes into their curricula have several factors to consider:

**Who contributes the content?** In many of the universities we surveyed the introduction of new courses, topics and tools appeared to originate from faculty members that are early in their careers. These faculty members bring new skills and knowledge from their PhD studies or industry experience to their new environment. At the same time, we observe a high demand for these new courses, and the faculty that introduce them may be capacity-limited, because they are pursuing tenure and thus have to balance their teaching obligations with their research agenda.

**How can we teach competencies using applications and examples?** Many digital topics allow for the application of technology in the classroom. Often, instructors have a choice between an inexpensive open-source solution (which often has limited documentation and support), or a commercial solution (possibly through the academic affiliation program of a software vendor), which may come with training requirements for faculty wishing to use these solutions. Business Schools are navigating a narrow path between educating students in relevant technologies, and arbitrarily having to pick "winner" or "loser" among the considerable portfolio of new technologies.

**Key questions:**

- **Who contributes the content?**
- **How can Business Schools teach competencies in a practical fashion?**
- **How can Business Schools manage the digital savviness gap between their own faculty?**

We observed that many universities have deployed the label "Digital" in course names and program designations as a marketing tool, in order to make existing content appear current and relevant. Not always has such rebranding been accompanied by a systematic revision of the actual curriculum content, which makes it difficult for prospective students to identify programs that at the course level introduce the Digital Era topics.

**How can Business Schools manage the digital savviness gap between their faculty?** The current COVID pandemic has brought with it a forced upskilling of many faculty members related to their online teaching acumen, but it has also laid bare deficiencies in digital literacy among Business School faculty. Deans and administrators should use this opportunity to identify development opportunities for faculty that will allow them to teach new topics using digital media.

We did find indication of regional differences regarding Digital readiness. In particular, Business Schools in Asia appear to lag behind Europe and North America in the incorporation of digital topics into the curriculum, while we received precious little data from Africa and South America.

# 5. Limitations

## 5.1. Data Availability

The curriculum evaluation was conducted based on publicly available curriculum data. The degree of detail available in this data varied by university. While some schools have syllabi available online, other schools only publish paragraph-length catalog course descriptions and make more detailed syllabus data available only to students enrolled in specific courses.

## 5.2. Level of Detail

As technologies evolve, instructors may introduce tools and techniques to the classroom without updating course descriptions or syllabi. Available curricula are therefore only a rough estimate of the level of digital technology applied in the classroom.

## 5.3. Data Sources across Task Forces

Each of the nine MaCuDE task forces collected curricular data independently, which limits the degree of inference possible across academic disciplines, due to different coding standards and data abstractions. Table 1 shows the curriculum sampling strategies employed by the different task forces.

*Table 1: Sampling Strategies for Curriculum Data*

| MaCuDE Task Force | Curriculum Sampling Strategy |
|---|---|
| **Accounting** | • Used Financial Times top 50 MBA rankings. Obtained additional data from 14 Task Force members from their respective schools. Supplemented with schools in underrepresented regions.<br>• Survey of over 100 accounting programs.<br>• Identified global accounting certification types.<br>• Evaluated the AICPA changes to the 2024 CPA exam. |
| **Analytics** | • Surveys posted on INFORMS, MSOM Society mailing lists.<br>• Collected 30 responses for Undergraduate and 36 responses for Graduate programs. |
| **Finance** | • Used Financial Times top 50 MBA rankings and Financial Times top 30 finance schools. Obtained data on 13 programs from 7 Task Force members. Supplemented with schools that are more tech oriented or are in underrepresented areas.<br>• Reviewed a total of 43 MS programs and 22 UG programs from Europe, North America, and Asia. |
| **Information Systems** | • Leveraged Association of Information Systems IS Curricular Database (EduGloPedia).<br>• Obtained data of 36 schools and 25 AIS council members for data collection at Undergraduate and Graduate levels.<br>• Leveraged AIS/ACM reference curricula in Information Systems |
| **Management** | • Used Financial Times top 50 MBA rankings. Obtained additional data from 5 Task Force members. |
| **Marketing** | • Surveyed top-100 schools based on the Economist global ranking, supplemented by members of the task force and a sample of AACSB-member schools that were not ranked in the top 100.<br>• The resulting sample set consisted of 31 undergraduate programs, 42 MBA programs, and 27 Master's programs.<br>• Reviewed a total of 319 courses. |
| **Strategy/Innovation / Entrepreneurship** | • Assessed 550 courses from the top 100 Business Schools (FT ranking) |
| **Future of Work/Learning** | • No curricular evaluation<br>• Leveraged Task Force Members to elicit future of work themes |
| **Cybersecurity** | • Surveyed the US News Top 10 computer science (CS) programs in the USA and top 2 abroad, as well as the top 10 business schools at both the Undergraduate and MBA level in the US and top 2 abroad. |

# 6. Outlook

This report outlines the current state of the art of digital themes within undergraduate and graduate management programs. Our findings show that many universities have reacted to the changes that the digital era has triggered by adding course content on analytics, artificial intelligence, ethics, and many other digital themes. Some of this content is firmly rooted in traditional academic disciplines, but much of it cuts across traditional boundaries. Analytics techniques are applicable in Accounting, Finance, Marketing, and Operations. Algorithms and Artificial Intelligence tools decide on advertisement placements, identify employees that should be promoted, determine layouts for integrated circuits, decide on stock levels and warehousing strategies, and affect many other business decisions. Business schools need to decide how such cross-cutting topics are managed in a world that is rooted in traditional departments and disciplinary thinking. The Digital Era not only challenges traditional business notions but it also brings challenges to managing the institutions that educate the next generation of business leaders.

In the next phase of the MaCuDE project, the task forces will collect insight from industry representatives as to what skill gaps they perceive and how the development pathways for new hires and established incumbents have changed in view of the Digital Era.

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For more information about the MaCuDE project, see: https://www.macude.org