The Future of Digitalization in Higher Education

A case-based perspective on how US univ
meet the challenge of digitalization

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Dansk abstract:

Fremtidens digitalisering på universitetet

Udviklingen af nye digitale teknologier påvirker i høj grad universitetsverdenen. Det er en udvikling, som både stiller nye krav til universiteterne, men som også giver universiteterne nye muligheder for at udvikle sig. Universiteterne har derfor et stort fokus på området, og på hvordan de bedst håndterer nye krav til pensum og kompetencer.

Denne Outlookrapport formidler erfaringer fra fire eliteuniversiteter i Californien og Boston. UC Berkeley, Stanford University, Northeastern University og MIT er digitale first movers, når det kommer til arbejdet med at introducere studerende, undervisere og hele fakulteter til de muligheder, som nye teknologier giver for forskning og undervisning. Casene kan give inspiration til den danske debat om at inkorporere digitale rebskaber i pensum og opkvalificere undervisere til at anvende dem i undervisningen.

Rapporten viser først og fremmest, at de valgte amerikanske universiteter har gjort udviklingen af nye teknologier inden for områderne computer og data science til en fremtrædende strategisk prioritet. Visionen er ikke blot at opruste inden for disse områder, men at udbrede og integrere den digtigle viden fra computer og data science bredt over alle fakulteter. Opgaven er ikke ligetil, og universiteternes tilgang til at løse den er forskellig. Fælles for dem er dog, at de har fokus på at skabe en interdisciplinær integration af digitale færdigheder med de studerendes respektive fagområder.

Dernæst viser rapporten, at universiteterne ser et potentiale for øget læring og undervisningskvalitet i nye undervisningsteknologier. Investeringer i EDU-IT skaber mulighed for at indsamle data om de studerendes læringsproces og i højere grad skræddersy undervisningen både online og on-campus til de individuelle studerendes behov.

Opkvalificeringen af undervisere sker i høj grad igennem frivillig deltagelse i kurser og workshops og ved at underviserne anvender tilgængelige platforme og læringscentre for hjælp til implementering af computer og data science i deres undervisning.

1 The digital challenge

Keeping up with the digital reality of today has become a major concern for many universities in Denmark and in the USA. Students are digital natives and demand education with seamless digital interfaces. Employers require new skills relating to data analysis and new technology. And educators see the potential for using digital technologies to provide new content and courses for students.

Being 'digital' is no longer about having rooms full of computers, printers and keeping the campus WiFi running smoothly. Being 'digital' instead means taking stock of how the large amounts of data and new methods to analyze these data will change *what* universities should teach. It also involves using new tools and technologies to rethink *how* courses can be taught. Importantly, the rise of digital technologies and data is relevant for all disciplines. Students must be able to understand and critically engage with the implications that digital technologies will have for their field of study.

The Danish Ministry for Higher Education and Science published an action plan for digitalization in higher education[1] in April 2019. The plan highlighted key challenges and recommendations to help Danish institutions overcome some of the challenges in the transformation to a more digital model of higher education. This Outlook sets out to bring US inputs to the debate surrounding this initiative by pursuing two of the questions raised in the plan concerning:

1. How universities can integrate new technology into curricula and provide students with new tools to analyze their field of study
2. How universities can use EDU-IT and upskill faculty to use new technology to deliver and support their teaching

The Outlook is informed by case studies based on interviews and visits to four US elite universities: UC Berkeley, Stanford, Northeastern University and MIT. These were chosen because of their proximity to two major tech-hubs and status as technological first movers with the hope that their experiences may provide inspiration and insight as to how these challenges can be approached in Denmark.

The Outlook will start with a brief overview of the state-of-the-art of digitalization efforts in higher education by highlighting the pace and extent of new courses, education centers and other strategic initiatives. Following that, focus will turn to the two

[1] Uddannelses og Forskningsministeriet (2019) *Digitale kompetencer og digital læring*

challenges by looking at changes in curricula and efforts to upskill faculty and utilize new educational technology. The key findings of these sections are:

- All four universities see digitalization as a strategic priority. The area is still under development, and we see different approaches to the organizational set-up. But all are investing in new courses, centers or other initiatives to introduce skills in computing and data science across departments.
- The universities differ in how they introduce digital skills into courses and curricula, but among the universities we see a common emphasis on integrating the digital skills with students' field of study.
- New educational technology has the potential to increase students learning by e.g. broadening the reach of courses, creating more flexible ways of learning or using data driven education to enable targeted teaching methods.
- The approach to upskilling faculty members to use these new technological tools varies considerably, but the common trend is that most of the implementation is based on a voluntary bottom up process.

2 Universities go digital

How US universities are investing strategically in new technologies and data science

2.1 Key takeaways

- The trend is clear: these US technological first mover universities all make the introduction of new technologies and data science a strategic priority and invest accordingly within the field.
- This priority is not only recognized by the universities themselves; their students flock to the courses that will teach them skills in these new technologies.
- The trend is less unified among the universities, when it comes to how this priority is implemented organizationally on campus.

2.2 Strategic focus on digital technologies and data science

Staying at the forefront of new digital technologies is a clear, strategic priority among all of the four universities in this report. This is prominently reflected in both the creation of new visions and centers dedicated to education and research for digital technologies, computing and data science.

UC Berkeley, among the best public universities in the world, announced in November 2018 a major structural change to establish a new Division for Data Science and Information. The mission statement for the Division is "redefining the research university for the digital age". To do so, the Division will engage with departments, schools and colleges across UC Berkeley to spur faculty hiring and education in data science-related fields. The announcement puts data science at the heart of the university's vision for how to deliver excellent research and education for the future. It also represents one of the most profound changes to the university's organization in decades.

Stanford University has also elevated digital technology in their latest vision for the university by defining "Shaping the Digital Future: Data Science & Human-Centered AI" as a major pillar in advancing all academic disciplines. But the chosen model of implementation for this strategic prioritization is quite different than the Berkeley model. Instead of creating a new center for data science, Stanford aims to weave data science research and education into activities across disciplines.

At Northeastern University, the Khoury College of Computer Sciences has grown rapidly over the last five years and will continue to do so for the next few years. As of now, the Khoury College of Computer Sciences has a total of eight master programs, five of which are interdisciplinary collaborations with other departments. "CS for Everyone" is the mission behind the development of the college.

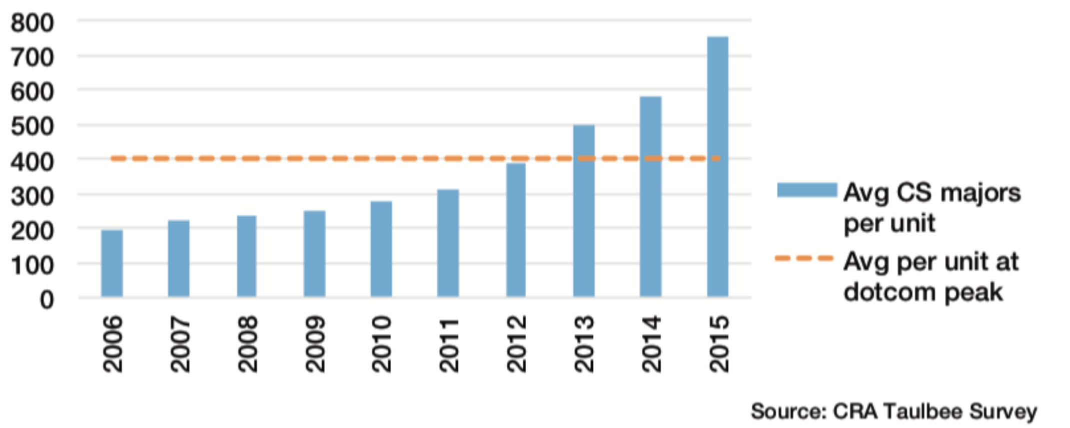
At MIT we see immense investments committed to digital technology. MIT announced in October 2018 that they will be reshaping their university to incorporate digital technologies and AI across all of their degrees. This is done by building a cross functional MIT Schwarzman College of Computing and providing AI, machine learning and computer science skills to all their students, regardless if they belong to MIT's School of Engineering or Humanities. According to the MIT president, Rafael Reif: "computing is no longer the domain of the experts alone, it is everywhere, and it needs to be understood and mastered by almost everyone." In fields far beyond engineering and science – from political science and linguistics to anthropology and the arts – there are burgeoning opportunities for current and future research to benefit from advanced computational knowledge and capabilities. The MIT Schwarzman College of Computing represents a $1.1 billion commitment by MIT, in part enabled by a $350 million private donation, the largest investment to date in computing at a university.

2.2 Increasing student demand

The immense investments in centers for education and research in digital technologies are motivated by major trends both inside and outside the universities. One important driver is increasing student demand for new technology as an integrated part of their education. At MIT, for example, the numbers of students declaring majors and choosing classes in computer science have reached historic highs. 800 out of 1,000 freshmen students at MIT take machine learning courses and 96 pct. of MIT student at humanities take courses in computer science. Stanford shows a similar pattern, with over 90 pct. of students enrolling in courses involving data science. At UC Berkeley, the introductory data science course Data8 was created in response to increased student demand for data and computer science related courses, without having to declare a major in either field. Since Data8's creation it has been an extremely fast-growing course and now about 50 pct. of all new undergraduate students enroll. The numbers almost speak for themselves. They visibly reflect the students' perceived need for acquiring skills in using these technological tools and understanding their implications.

However, the high student demand for computer and data science did not evolve over night. It has been continually growing over time among students across the US. The Computing Research Association (CRA) have mapped the enrollment trend among more than 200 divisions offering computer science bachelor's programs in North America since 2005[2].

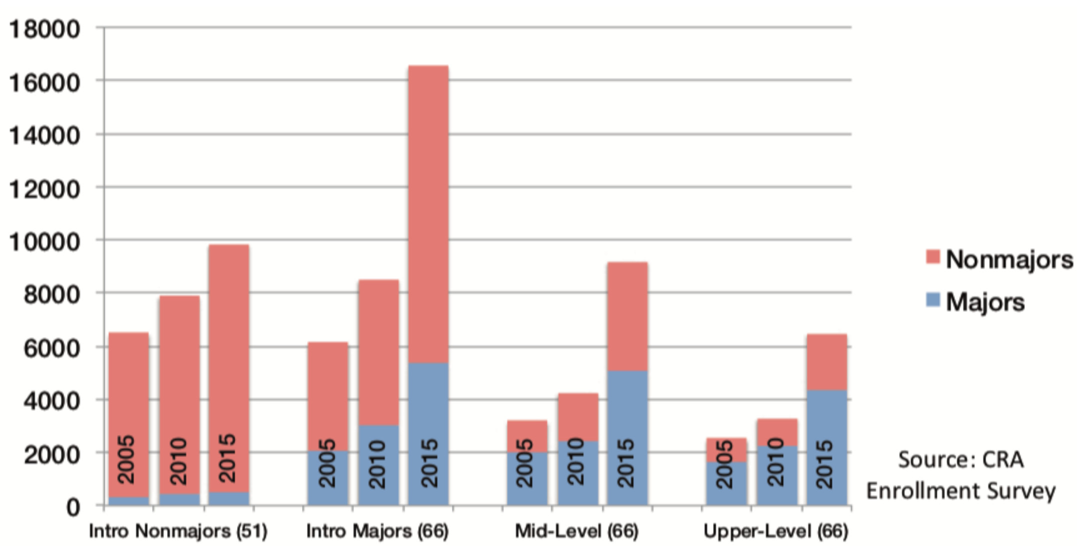
[2] https://cra.org/data/generation-cs/



Graph showing average number of computer science majors per administrative division responsible for a computer science bachelor's program since 2006[3]

What can be concluded form the CRA surveys is that we have seen a growing average number of undergraduate computer science majors per computer science division since 2006. In the period after 2013 the level has dramatically exceeded the peak in enrolment numbers from the dot-com boom period, which was historically high.

This is not only the case for the computer science major students. The graph below shows, that enrollment have been continuously increasing for both computer science major and nonmajor students since 2005. Apart from this, it also illustrates how the upward enrollment trend is the same case across all curriculum levels.



Graph showing cumulative nonmajor enrollment (red) and major enrollment (blue) in computing courses at both doctoral and non-doctoral granting units from 2005-2015. The number in parentheses in each category indicates sample size[4].

[3] Graph form the CRA report: "Generation CS: Computer Science Undergraduate Enrollments Surge Since 2006" https://cra.org/data/generation-cs/phenomenal-growth-cs-majors-since-2006/
[4] Graph form the CRA report: "Generation CS: Computer Science Undergraduate Enrollments Surge Since 2006" https://cra.org/data/generation-cs/impact-nonmajors-enrollments/

2.4 Different approaches to implementation

Even though the universities have experienced a similar student demand for digital skills, and they have answered by making this a strategic priority, the implementation of these strategies is very different. This difference stems from differing views on the important question of how to organize the implementation of new technology and data science into the university.

One approach is to concentrate efforts by creating a new unit with crosscutting activities involving the entire university. For UC Berkeley, the Division for Data Science and Information has created a visible champion that can drive efforts. The same can be said for MIT's College of Computing, that is also an example of implementing new technology and data science by creating an entirely new unit cutting across all five schools at MIT. Another approach is to support a more decentralized approach by promoting several efforts at individual departments. Stanford University exemplifies this approach, with data and technology centered efforts happening across the university. One reason, perhaps, behind the Stanford approach is that the university has a strong reputation for precisely technology and data science, thereby making a central champion less necessary.

3 Digital curriculum

How universities integrate new technology into curricula to provide students with new tools to analyze and engage with their field of study

3.1 Key takeaways

- The spectrum of the digital courses offered is extremely broad, diverse and focus on various fields.
- Among the courses we see a balance between aiming at giving the students a digital literacy and basis understanding vs. teaching them hard skills in computing.
- An important dimension is the degree and model of interdisciplinary integration of the digital knowledge. The integration of digital skills is done with the goal of making the students better able to pursue questions and do research in their own fields of study.

The universities are similar in their emphasis on new technology in education but very different in how they integrate it into curricula. Two dimensions highlight the difference between the universities. First, the balance between teaching soft skills and data literacy vs. hard technical skills and second, the degree to which this acquired knowledge is integrated with the students' specific field of study.

3.2 What to teach: Digital literacy or hard technical skills?

One important consideration when incorporating new technology and digital skills into curricula is figuring out which students need to learn what. What skills are necessary for all students, and what skills are more suitable as optional specializations for certain students?

Another consideration is that students across disciplines have different prerequisites for learning highly technical tools like machine learning and AI. Students of natural sciences and engineering typically have a higher propensity for math-based methods than students from social sciences and humanities. Conversely, students of social sciences and humanities might be more familiar with ethical discussions surrounding use of data and AI.

UC Berkeley approaches this consideration as a question of how to make data science accessible to all students. Their answer is to offer a diverse catalogue of data science-related courses to students at different levels and with different prerequisites. Introductory courses create a level playing field, upon which students interested in more depth can progress to advanced courses. This approach is especially functional in the structure of US undergraduate degrees, where students can choose courses more freely across disciplines and faculties.

On the less technical end, courses without any course prerequisites aim at giving the students a coding literacy. They introduce students to the basics of coding and enable them to know the principles of e.g. machine learning and discus what it can be used for. An iconic example of a course of this type is Data8 at UC Berkeley, which has been one of the most popular courses in terms of enrolment numbers in UC Berkeley history.

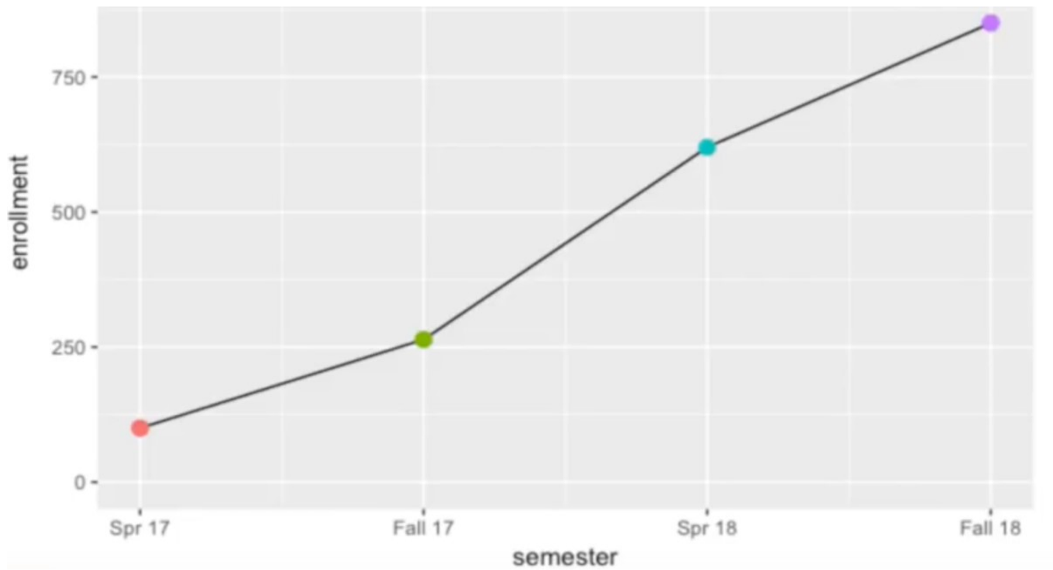
Data8 teaches programming and data science to undergraduate students across faculties using data from fields as varied as biology, business and geography. The course focuses on teaching the basics of inference and computing to give students a new lens through which to explore real-world issues. The Data8 course also includes contextual topics, such as data privacy and bias in AI or machine learning to ensure that students understand the ethical and democratic implications of the use of these technologies. Approximately 3700 Berkeley students per year enroll in this course, which is about half of all new undergraduate students.

Photo of a Data8 lecture at UC Berkeley[5]

On the more technical end, other courses teach coding as a hard skill, where the students are to a larger extend taught to code themselves, e.g. predict outcomes, cross-validate functions or use SQL. Of this more computationally demanding type of courses, The Division of Data Science and Information at Berkeley has created the Data100 course that students can only enroll in after having completed Data8 and courses in math and computing.

[5] Photo from https://data.berkeley.edu/education/courses/data-8

Data100 is a course open to students from all majors and levels who meet the prerequisites of having completed courses in the foundations of Data Science (Data8), Computing and Math. During the course the students will do data collection and cleaning, exploratory analysis, visualization, statistical inference and prediction to such an extent that they will to able to solve problems and possibly pursue more data competencies and a career in Data Science. In 2018, about 1500 students enrolled in Data100 and, as the graph illustrates, the trend is clearly upward.



Graph of Data100 enrollment[6]

3.3 How to teach: General introduction or interdisciplinary integration?

Another important dimension concerns the degree to which technical tools and approaches are integrated into the different specific subject areas. The UC Berkeley courses Data8 and Data100 are general, or even generic, in the sense that the premise in both courses is that the all students learn data science in the same way regardless of their existing study program. The lectures, materials and assignments are the same whether you studied math or literature.

On the other end of the spectrum, an increasing amount of the courses offered are designed to create an interdisciplinary integration by focusing on the application of data science techniques to specific academic subjects. The goal of these courses is not to teach data science for the sake of data science, but to teach those data science techniques and tools that will enable the students to better study their own field. The difficult question here is: how exactly do you do that? How to incorporate data science into diverse curricula and in such a way that you can make an archeology student a better archeology student and a language student a better language student? This kind of interdisciplinary integration often requires courses that to a higher degree are tailored to different fields of study. This is the case with the connector courses at UC

[6] Graph from https://data.berkeley.edu/education/courses/data-100

Berkeley.

The connector courses offered at UC Berkeley are created with the central idea that students apply data science skills obtained through Data8 to solve specific problems within their own fields of study. As the brief overview of some of the offered connector courses below shows, students of biotechnology can e.g. take a course that utilizes data to answer questions about immunotherapy of cancer, while students of geography can use data science techniques to study spatial data. The connector courses combine both curricula and instructors from departments across campus.

Graphic showing selected connector courses at UC Berkeley[7]

Another, and quite different, perspective on how to achieve interdisciplinary integration can be found in the Data Science Modules at Berkeley. The modules are shorter explorations into data science, where the students get hands on experience with a data set that is relevant to a course they are *already* taking. For example, a course teaching students of rhetoric speech analyses can integrate a module that applies data science techniques to quantify political speeches across time. The modules are designed specifically for that course and taught in that course. In this way, students are not introduced to data science by signing up for a separate data science course, but through a course they are already taking. The modules introduce students that would not themselves sign up for data science to its possibilities within their own field.

The Data Science Modules are powered by undergraduate students that work in teams to create data sets in the cloud-based notebook Jupyter and mini coding lessons, charts and graphs for the course the modules are made for. When designing these modules, the development team meets with the course instructor to understand the students' data science prerequisites and how data science can be used to enhance the learning objectives of the course. The team of undergraduate students are then given the task of making the data and developing the notebook. After feed-

[7] Graphic from https://data.berkeley.edu/education/connectors

back from the instructor, the module can then be taught in class either by the instructor or with aid from the team of undergraduate students.[8]

3.4 Interdisciplinary digital programs

At Stanford, there has long been a focus on the importance of interdisciplinary integration of digital skills. Since 1986 the Symbolic System Program has developed a curriculum that combines traditional humanistic approaches with science and the technology of computation. The program is inherently interdisciplinary drawing on the three main fields: cognitive science, artificial intelligence, and designing computer software and interfaces. The Symbolic System Program is unique in its success by bringing together students from different faculties with an interest in human-computer interaction, and in its way of approaching questions of digitalization from perspectives that reach beyond computer science.

The Symbolic Systems Program offers both undergraduate and graduate programs. It combines courses in computer science, linguistics, philosophy, psychology and statistics and is affiliated with different departments at Stanford. Its goal is to explore different aspects of intelligence and human-computer interactions and thereby prepare the students to participate in interdisciplinary research and collaboration related to our digital future. Alumni of the Symbolic Systems Program are today researchers in a broad variety of research fields, spanning from business, communication, computer science to law, psychology and public health [9].

More recently Stanford has experienced an increasing demand from a growing number of humanities faculty experimenting with digital tools and an acknowledgement of the need to carry out humanities research in new ways. This led Stanford to develop a digital humanities minor in 2015 that combines scientific and computational methods with interpretative and critical thinking skills. The minor consists of six courses within one of three Digital Humanities clusters: geospatial humanities, quantitative textual analysis, and text technologies. The initiative gives the students the opportunity to blend humanistic research with technological knowledge and methods.

Northeastern University also focus on the interdisciplinary integration of computer and data science with other fields. As a way to help people from all fields pursue a career in the tech industry, Northeastern University offers a M.Sc. in Computer Science through the so-called Align Program. The program is built around core coursework in program design, networks, and software development specifically designed for students with non-computer science backgrounds. Elective courses in e.g. machine learning, networks and security allow students to tailor their degree to their unique interests.

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[8] Read more on https://data.berkeley.edu/education/modules
[9] Read more on https://symsys.stanford.edu

The Align Program got off the ground with seed funding from companies and venture capitals. As part of the investment, three other universities — Columbia University, Georgia Tech and the University of Illinois at Urbana-Champaign — will use best practices from Northeastern to create "pathways" into their computer science master's programs for people from non-tech backgrounds. Facebook and Northeastern want to build a consortium of at least 15 US colleges and universities focusing on increasing diversity in computer science.

The Align Program at Northeastern University provides a direct path to a Master's in Computer Science for non-computer science majors and people without programming experience through six semesters. The program is specifically designed for students with non-computer science background with the objectives of:

1) Developing the ability to recognize and solve problems arising in computing
2) Assimilating ideas and concepts from theoretical studies and hands-on design and programming, and
3) Acquiring skills in software and application design, network infrastructure, and other dynamic and emerging computer science areas.

The program began in 2013 and today there are 575 students enrolled across Northeastern's locations in Seattle, Boston, Silicon Valley, San Francisco and Charlotte[10].

3.5 Not anything goes – challenges to consider

However inspiring the computing and data science initiatives in California and Boston may be, it is important to draw attention to the fact that it does not *always* go well. The CS+X program at Stanford tells the story of how different kinds of barriers of success can occur in terms of program design, coordination, planning and departmental conflicts.

The CS+X program at Stanford is best described as a program failure. The program began in 2014 as an interdisciplinary teaching experiment that allowed undergraduate students to pursue a "joint major" combining computer science and a chosen field of study in the humanities. The intention was to integrate humanities and computer science and utilize the synergies of acquiring diverse skills to stimulate student's interests and abilities in both fields. Unfortunately, the program enjoyed limited popularity among students, and few completed the joint major. As a result, the program closed by the end of the spring quarter of 2019. The CS+X program suffered from a number of flaws with cross-departmental programs: insufficient integration of the two disciplines, administrative challenges in scheduling classes and creating community between students, and academic turf wars between departments. Students also cite the heavy workload and lack of flexibility in the requirements of both departments as a reason for the program's failure[11].

[10] Read more on https://align.khoury.northeastern.edu
[11] Closing announcement on https://news.stanford.edu/2019/01/24/csx-pilot-discontinued-end-spring-quarter/

However, Khoury College at Northeastern still offers a wide range of these combined majors, also known as "CS+X", that pair a computer or information science degree with another area of study. Therefore, no matter the students' background they will be able to gain a strong technical foundation and an understanding of how computing concepts apply to their chosen domain. Each of the combined majors offers the opportunity for intense study in two disciplines with appropriate breadth in the liberal arts. The combined majors consist of nine to 13 courses in each subject and at least one integrative course that binds the disciplines together.

With Stanford's "CS+X" experience in mind, MIT College of Computing plans to structure and create so-called bi-majors in a similar way to the construction of combined majors at Northeastern. However, they point out that it is important to incentivize faculty to create such integrated offerings.

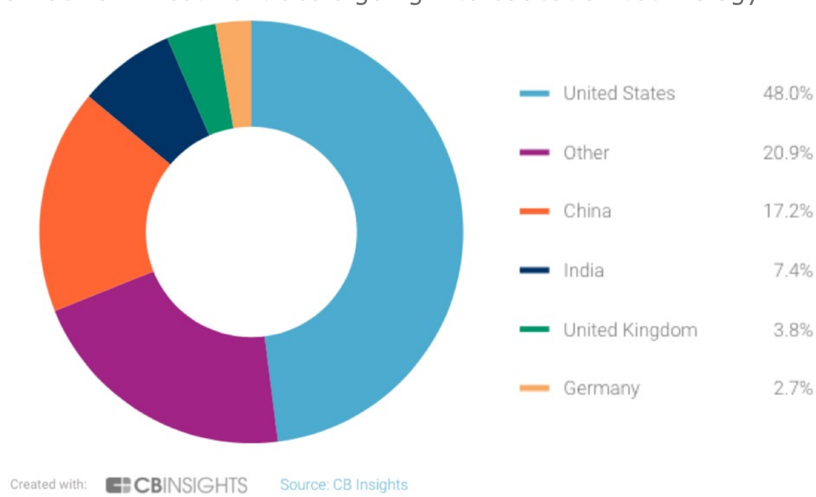
4 EDU-IT and digital faculty

How universities use EDU-IT and upskill faculty to use new technology to deliver and support their teaching

4.1 Key takeaways

- EDU-IT holds the potential to increase students' learning with data driven education being more adaptable to the individual learning path and enabling teachers to tailor their teaching to different student needs.
- The universities have invested in institutions and the building of a digital infrastructure to reap these benefits.
- We see different approaches to the upskilling of faculty to use these tools, but they are all driven by voluntary implementation efforts from faculty members.

The rise of digital technology not only provides students with new possibilities for exploring their field of study. It also provides universities with new educational technologies and tools that can increase the quality of higher education. The US context poses an especially interesting case for an outlook on how the universities use of these educational technologies, since the US is the country in the world with by far the largest number of investment deals going into education technology.



Graphic showing investment deals in EdTech from 2014-2019 by countries.

The use of new EDU-IT tools to deliver and support teaching holds the potential to improve teaching in multiple ways. But fully realizing this EDU-IT potential requires that educators and faculty have the right skills to use these new tools. This section therefor focusses on how universities can support faculty to deliver higher education digitally with the use of new technologies. The case studies will provide examples of both *which* EDU-IT tools and digital platforms the universities in California and Boston use and *how* the universities upskill faculty and make instructors across all departments curios about the possibilities in exploring their academic field with the use of new technologies and passing this knowledge on to their students.

4.2 The movement towards digitalization

The movement towards developing and deploying EDU-IT and upskilling faculty to do so springs from the belief that the introduction of new technology holds potential to improve university education by enabling accessibility, flexibility and better possibilities when it comes to targeted teaching methods. The move from physical teaching spaces to digital interfaces allows data collection on students' behavior, interactions and understanding of the coursework. This movement allows educators to identify, measure and monitor sections that are particularly challenging for students and require more attention or explanations during lectures. Such data-driven teaching allows for a more targeted teaching approach and aids in transforming the role of the lecturers from teachers to guides in the student's individual search for knowledge

As an example of how these technologies can be deployed in higher education, Stanford University's School of Engineering is at the forefront when it comes to digitalizing the format of teaching and using digital tracking on their students' interaction with the course material.

The Stanford School of Engineering has digitalized much of its course material to increase accessibility to students. The digital course material is furthermore designed to include the option of accompanying certain sections of the course material by a video explaining and elaborating on the core concepts or especially difficult parts of the material. This feature can be helpful and time saving to both students and lecturers. Another advantage of this digitalized curriculum lies in its digital tracking function that allows for instructors and lecturers to monitor their students' interaction with the course material. This feature enables lecturers to identify sections that are particularly challenging for students and get a more accurate impression of how much time students spend on course material. The monitoring is also useful to another end. Since the student's assignments and course work are digital, these can be made interactive to adjust difficulty based on the correctness of students' previous responses. This feature of targeted learning enables students at all levels to develop and maximize learning across individual levels.

A professor at the School of Engineering described the creation of an online platform "as the first step towards creating a fast pass to success in teaching students", since it becomes much easier for students to identify gaps in their own knowledge, and for lecturers to identify weaknesses in their curriculum or lectures and mend them. Therefore, the Stanford School of Engineering has implemented the digital platform in many of their education practices, and the university as a whole continues to implement online or digital learning tools in other areas.

UC Berkeley has similarly developed an online platform for their flagship data science course Data8. All materials for the course, including the textbook, assignments and lecture materials are available for free online under a Creative Commons license. The infrastructure for the course and most other materials developed by the Berkeley Division for Data Science and Information are additionally maintained as open-source projects. The open and easy-to-use platform has proved to be important for spreading data science across Berkeley, since students and faculty interested in data science do not need access to expensive programs.

Likewise, at MIT investments have been devoted to creating EDU-IT solutions and online platforms. MIT have developed the OpenCourseWare (OCW) which is a free, open, publicly accessible web-based resource that offers educational materials from more than 2.450 MIT courses – virtually the entire MIT graduate and undergraduate curriculum – reflecting the teaching in all of five MIT schools and 33 academic units. Educators use these resources for teaching and curriculum development, while students and self-learners draw upon the materials for self-study or supplementary use. Through OCW, MIT faculty also share their teaching materials with a global audience of teachers and learners. MIT also developed MITx, which is not only an online platform for course material, but a platform for taking an online version of MIT courses.

MITx is an interactive learning initiative at MIT that offers online version of MIT courses on the so-called edX, a partnership in online education between MIT and Harvard University. MIT instructors teach these MITx courses to learners on-campus and around the world. The learning experience of the courses feature multimedia and video content, embedded quizzed with immediate feedback, online laboratories, and peer-to-peer communications. The content of the online course materials is the same as the on-campus courses but organized and presented in ways that enable students to learn at their own pace and that allow for the individual assessment of each student's work. MITx operates on a cost-free, open-source, scalable software infrastructure. The vast array of data gathered through MITx global and residential uses is helping educational researchers better understand how students learn and how technology can facilitate effective teaching both on campus and online. Research findings are then introduced into new generations of learning tools, creating a continuous loop of educational innovation[12].

[12] Read more on https://www.edx.org/school/mitx

MITx also created their MicroMasters programs. MicroMasters programs offer professional and academic credentials for online learners from anywhere in the world. A typical MicroMaster program consists of five to eight online courses on edX. Learners who pass the integrated set of MITx graduate-level courses on edX, and or more proctored exams, will earn a MicroMasters program credential from MITx. In addition to this, the MITx MicroMasters also adds new pathways to master's degree at MIT. With this credential, learners can also apply for an accelerated, on-campus master's at MIT. If they are accepted, they can attend classes at MIT's campus and complete a capstone project before earning a master's degree. These examples illustrate how MIT has seen the new educational technologies as a possibility to get in touch with a global audience of students.

4.3 How to upskill faculty to use new technology?

After looking at some examples of which kind of EDU-IT tools and digital platforms the universities use, the next question is, how do they upskill faculty so that these new possibilities will actually come to live in the design and conducting of teaching.

The UC Berkeley answer is to approach faculty through workshops and make sure that they have access to all the necessary tools and help they need to make their courses more digital. Every summer The Division of Data Science and Information hosts voluntary workshops where faculty members from all departments can come and see examples of how they can utilize new technology in different fields and deploy it in class. The Division aids any department interested in offering a course with data or computer science content with the digital infrastructure and advice on how to build the curriculum and ease the take-off. This service has been vital to the large scale spreading of data science across the UC Berkeley campus.

The workshops at The Division of Data Science and Information are three-day long and open to all faculty to sign up. During the workshop the faculty members will receive lessons from Data8 to get insight in data science and its possible applications. They will also be exposed to examples of how data science has been incorporated in classes across campus. Students that worked for the Modules Program will attend the workshop and explain how they integrating data science in different courses.

Photo of Eric Van Dusen hosting the workshop this summer[13]

Eric Van Dusen, who is a curriculum coordinator at Berkeley and host of the summer workshops, points to the importance of having enthusiastic students come and show how data science can be brought to life in real classes in order to motivate other faculty members to do the same. Asked what the recruiting strategy for the summer workshop is, Eric Van Dusen furthermore explained how he believes that instead of aiming at the highest possible number of faculty attendees, it is a more viable strategy to attract a few highly motivated faculty members from each department that can set an example and become local stakeholders within their respective departments.

The Division also offer continuing education to faculty on using data and computer science techniques to improve the quality of their own research. This increases the willingness of researchers from diverse academic fields to participate in the digital upskilling, because of the perceived importance of these tools in keeping their research on the forefront and increase the replicability.

Stanford University has also invested considerable resources in the upskilling of faculty for the digital age. Stanford University has built a Center for Interdisciplinary Digital Research (CIDR) with expertise in data discovery, data creation, data management and analytical tools to support the use and generation of these data by researchers. CIDR works to enable interdisciplinary research in social sciences and the humanities by developing new tools to integrate technology. CIDR facilitates courses, workshops and seminars in digital methods to Stanford affiliates. These include introductions to the open-source statistics program R, the programming language Python and creating data visualization with the software platform Tableau.

Another way CIDR spreads its knowledge and gets faculty across disciplines to open their eyes to digital tools is by placing some of its affiliates, known as academic technology specialists (ATS), among the regular faculty in different Stanford departments and schools. By providing all of these initiatives CIDR has positioned itself as a digital knowledge hub that both students and teachers can come to for guidance on how to take advantage of the new technological possibilities.

Academic technology specialists are experts in technology and the academic field that they are placed in. With this double affiliation they serve as a liaison from The Center to the faculty which help integrate technology broadly in academia, and support staff in developing reusable digital tools and improving existing digital tools for a variety of disciplines. Much of the work related to building a research relevant digital tool can be used again on another project but this is often not shared between departments or even research groups. The presence of the ATS eases the process of making reusable digital tools because they serve as a "go to-person" in their department and know what relevant digital tools that already exist for different research projects.

[13] Photo from https://data.berkeley.edu/academics/resources/data-science-education-workshops/2019-national-workshop-data-science-educationnational-workshop-data-science-education

The universities clearly have different approaches to the upskilling of faculty both in terms of the use of EDU-IT and incorporating new technologies in the content of their courses and research. Some host workshops, some create courses for faculty members, some place experts in different departments while others create a central unit for this upskilling. The differences apart, all of these initiatives have one thing in common: all of them are optional for the faculty members to attend or use, and in this sense the implementation strategy for the digitalization of faculty is, more than anything else, voluntary.

4.4 Potential drawbacks about EDU-IT: cost and return

At the same time, there are potential drawbacks to keep in mind when considering digitizing coursework and implementing EDU-IT: the significant upfront costs and the fundamental question of when digitization promotes better learning.

Regarding costs, experience from Stanford shows that the initial investment to digitalize curriculum, assignments etc., is substantial, the return is not immediate, and it will require on-going maintenance and updates. Second, many of the benefits associated with a digitalized curriculum require lecturers and instructors to access the data, and actively use it to track student behavior, and analyze the output and act accordingly, which requires continuous dedication. Third, digitalizing the curriculum in STEM-fields tends to be more straightforward than in social sciences or humanities fields with heavier emphasis on textual analysis or writing.

Stanford is also seeing a growing countermovement arguing against the use of electronics during lectures[14]. Parts of the Stanford faculty have banned the use of laptops, phones and tablets during lectures. The research on the use of electronics demonstrates two factors at play. First, research has repeatedly shown that students learn less when using laptops for note taking rather than pen and paper[15]. Second, there are considerable negative externalities of laptop use[16], as students sitting near a peer using a laptop on average learn less than students who do not[17]. Note taking using a pen and paper is now the norm in some courses ranging from computer science to communication. Laptops are still encouraged in preparatory work.

The focus on laptop as an educational technology that is useful in some situations, but not all, is becoming more prevalent. The digital countermovement at Stanford demonstrates an important sentiment in the world of higher education concerned with how we need to be critical and reflected about how and when we use EDU-IT.

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[14] Zhu, Erping et al. (2011) "Tomorrow's Teaching and Learning" in *CRLT No. 30*
[15] Mueller, Pam and Daniel Oppenheimer (2014) "The Pen Is Mightier Than the Keyboard: Advantages of Longhand Over Laptop Note Taking" in Psychological Science
[16] Dynarski, Susan (2017) "Laptops Are Great. But Not During a Lecture or a Meeting" in *The New York Times on Nov. 22nd, 2017*
[17] Sana, Faria et al. (2013) "Laptop multitasking hinders classroom learning for both users and nearby peers*" in Computers & Education No. 62*

About ICDK Outlook

ICDK Outlook is written by the Danish Ministry of Higher Education and Science's Innovation Attachés.

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