A NATIONAL DIGITAL INFRASTRUCTURE FOR HIGHER EDUCATION

Bendik Bygstad, University of Oslo, Department of informatics, bendikby@ifi.uio.no
Egil Øvrelid, University of Oslo, Department of informatics, egilov@ifi.uio.no
Lars Oftedal, University of Oslo, USIT, lars.oftedal@usit.uio.no

Abstract
Historically, universities and institutes have developed their own IT solutions for education and research. This has worked well but constitutes today a challenge for digitalization because fragmented solutions are expensive and an obstacle for interaction and cooperation. In addition, universities are challenged by new actors. Our research question is, how can a digital university be conceptualised and governed? And how should universities relate to the larger national and global digital ecosystems of higher education and research? Our empirical evidence is a study of the Norwegian Higher Education sector with a particular focus on the University of Oslo. We find that the sector, being unique in the world, has developed some successful shared solutions, and is also establishing a coordinated governance regime. Our contribution is to propose an Enterprise Architecture for higher education, and to discuss the sector solutions in a digital infrastructure perspective.

Keywords: digital infrastructure, higher education, enterprise architecture

1. INTRODUCTION

We could regard a university as a platform ecosystem, bringing together students, professors and knowledge. Today, most universities are in the process of digitalisation, moving from application-oriented IT strategies to more holistic visions of digital organisations. There are several drivers for this development, such as new cohorts of digital native students expecting modern solutions, the increasing availability of digital technologies in education and research, economic pressures from government and funding bodies, and increased competition from other actors (Marshall, 2018). This leads to a number of new challenges.

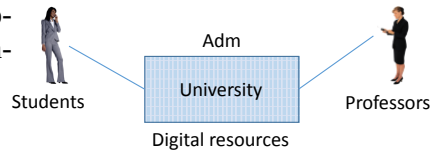

Figure 1: University as a platform

From a practical point of view, these issues challenge the traditional organisation of IT at universities. Broadly speaking, most universities established an IT department in the 1980s who has provided the central administrative solutions and infrastructure, while the researchers have acquired or developed local solutions. In the meantime, students have become used to social media, and often bypass the internal solutions. It is generally acknowledged that this division of labour has serious limitations, but the new solutions are not obvious. From a research view the digital university has not been much discussed, with a few exceptions, such as *The Digital University: Reinventing the Academy* (Hazemi et al., 2012), which deals with both teaching, research and digital systems. A number of separate issues have been researched, such as distance learning and MOOCS, digital divide, digitalisation and learning, and learning analytics (Simeon et al., 2015).

Universities are some of the most durable institutions in society. Their success can probably be attributed to their inherent conservativism in structures and academic processes, but also to their ability to change

and adapt. Universities have been pioneers in the uses of digital technologies, but digitalisation presents a number of new challenges and opportunities:

Generally, the universities must deal competently with increasing complexity of technology, architecture, and data, including security issues (Educause, 2018). Most universities have a large number of applications, often poorly integrated silo solutions. Adding to this, many universities around the world struggle with their financial situation, and are forced to downsize when they ideally should increase investments (Marshall, 2018).

In research universities must balance local project needs with digital order and scale. The dominating trend is to centralize, ideally combined with close co-operation between research and IT (Ludvigsen et al., 2019). This is easier said than done.

In education students expect modern digital services (being used to social media), requiring student-centric solutions instead of administrative (Pucciarelli et al., 2016). New entrants, such as Microsoft and Google, are often better to deal with this.

In *dissemination and innovation* many universities lack the necessary networks with private and public actors. Digital competence may be a key for new initiatives (Pucciarelli et al., 2016).

In administration there is increasing financial pressures (Marshall, 2018). One way forward is a better application portfolio governance; another is scaling with cloud services, robotic process automation and machine learning.

In the foreword to *The Digital University* Ben Shneiderman commented, «the turbulence generated by the integration of information technology into higher education provokes more conversations than the weather. The hot winds of hyperpromises and the cold front of angry skeptics are clouding the judgment of administrators, faculty members, and national planners. A clear forecast is not likely to appear until implementations are in place and thoughtful evaluations are conducted» (Hazemi et al., 2012, p. xxi).

To contribute to the on-going discourse, in this study we explore the issues from an infrastructure view which does not primarily address the policies, but rather investigates the sociotechnical network of actors and technologies. Our research questions are:

- How can a digital university be conceptualised and governed?
- How should universities relate digitally to the larger national and global ecosystems of higher education and research?

In asking these questions we build on the conceptualization of digital infrastructures (Hanseth and Lyytinen, 2010), as an installed base of users and technology providers, linked together by relatively open heterogeneous networks and standards. We develop our argument by suggesting an enterprise architecture model.

2. THE UNIVERSITY AS AN DIGITAL INFRASTRUCTURE

Infrastructure theory is based on the insight that IT and Information Systems increasingly operates as networked information and communication channels where systems, organizations, and agency are interconnected (Hanseth and Lyytinen 2010). These infrastructures are conceptualized in several different ways (Henfridsson and Bygstad 2013); as a complex multitude of actors with a range of different goals and motives; as networks of human and technical elements that evolve into increasingly larger entities; as relational systems that evolve through the sensemaking of the various users; and finally as the result of an alignment between business and technology resulting in increased strategic ability. Lately, infrastructures have, in one way or another, been seen as digitalized portfolios of systems (Tilson et al., 2010), and platforms and ecosystems (Rolland et al., 2018).

In business and public sector digitalization, there is an increasing trend to aggregate the infrastructures into more consolidated and manageable structures in order to simplify and streamline the governance of these infrastructures. This tendency has been called *platformization* (Bygstad and Hanseth 2018), which

describes a way of understanding the evolution and consolidation of digital infrastructures towards more coherent entities.

The infrastructure research has mainly been oriented towards e-health and private sector challenges, and to a lesser degree the higher education system. A university is basically a portfolio of departments, with an administrative, but not really co-ordinating, centre. According to Burton Clark (1983), the higher education system consists of management and administrative structures that are positioned above disciplines with a *complex aggregate of specialties*. These specialties, or disciplines, have evolved autonomously for many years and are very difficult to manage by the overlying structures.

Nevertheless, digital infrastructures are growing in academia, both in education and research. For instance, there is a growing interest in how to include social media in education (Manca and Ranieri, 2016), and in research there is an increasing interest for digital academic entrepreneurship in large networks (Rippa and Secundo, 2018).

Our perspective is how the university can be seen as an evolving digital infrastructure and ecosystem, and how digitalization efforts in higher education condition the institution. To our knowledge, this perspective has not been applied earlier. One key question is, how should such initiatives be organised? The EUNIS agency regularly benchmarks the IT of European universities on centralised vs. decentralised services, and costs of units and services, showing great variations. A central issue is the interplay of central vs. local solutions and governance (EUNIS, 2018). In USA, a new digital strategy for Penn State University emphasized the need for optimization and centralisation of IT resources (Kubit, 2018), mainly because of financial pressures. In the same line, the IT Master plan at the University of Oslo recommended a centralisation of resources, but also a "hub-node" structure for supporting research. Regarding the larger ecosystems, the Norwegian government established in 2018 a new directorate, UNIT, to co-ordinate the digitalisation of the higher education sector and research.

How deep is the current digitalisation? The importance of some trends has been overstated. In the media, there have been visions of the disruptive changes of education and learning from digital technology. However, in a student survey, "What works and why? Student perceptions of 'useful' digital technology in university teaching and learning" Hendersen et al., (2015) found that students use an increasing number of digital resources, but there is no evidence that this «transforms» learning or institutions. Another example is MOOCS; around 2010 it was predicted that these solutions might become dominant, and make traditional universities obsolete. Since then it has become clear that MOOCS is a supplementary service, very useful for students who cannot stay at a university, but not disrupting the universities (Siemens et al., 2015.)

Other trends may be underrated. The large Internet companies, such as Google and Microsoft are introducing new services, which are adopted by students, but not taken into the formal structures. For instance, Microsoft Teams and Google Docs offer collaboration services that may be easier to use for the student than using the LMS, because they are more integrated with other tools that the students already use. This is the logic of platforms, and hard to compete with.

3 ANALYTICAL LENS: ENTERPRISE ARCHITECTURE

To develop our argument, we suggest Enterprise Architecture (EA) as analytical lens. EA aims to deal with the complexities of IT solutions, and to align business and IT needs through a holistic view on business processes and IT systems (Zachmann, 1987; Open Group, 2018). Two main motivations behind EA is the aim to manage complexity, and to relate value creation directly to IT resources (Ross et al., 2006). The key to managing complexity is classification, and the Zachman framework is a classification system to describe the knowledge about the enterprise and the services. Later, a number of frameworks have been introduced to guide EA practice, among them the Open Group's TOGAF, which has now reached version 9.2 (Open Group 2018).

The field of EA comes from the IT domain. For instance, Armour et al., (1999) define EA as a holistic view of the enterprise's IT resources and views EA as the set of processes, tools and structures necessary to implement an enterprise-wide coherent and consistent IT architecture for supporting the enterprise's

business operations. Over the years, enterprise architecture has grown to encompass more than enterprise-wide IT architecture and is now increasingly concerned with the architecture of the whole enterprise (Fehskens 2008, Greefhorst and Proper 2011).

Martin (2012) investigated a huge federated pharmaceutical organization who strived to use Enterprise Architecture to model its complex business model in order to improve its IT strategy. Doing this he also inspected how architecture and strategy can be aligned, for instance by relating business processes and lower level services, systems and infrastructure within the same model. Martin's findings do also reflect the challenge of alignment in large-scale structures where decentralized autonomy is particularly strong. Martin, then, demonstrate the difficulties of aligning organizations without a unifying model, and the implications may often be slow progress and frustrated architects.

The model Martin develops is particularly helpful in our setting, which is the higher education sector. The Norwegian Government (Norwegian Government 2017A, Norwegian Government 2017B) have established a directorate, UNIT, to strive for consolidation of common digital requirements in the sector. They will, however, encounter some challenges since the higher education system contains a complex aggregation of specialties (Clark 1983). Martin's investigation, then, can be used as a warning, but also as an inspiration. Martin's model is based on an MIT framework. It consists of relating the external environment, the strategy, the various structures, the management processes, the individual roles and last but not least the technology to each other. His visualization based on empirical findings will be applied to our findings in section 5. It demonstrates how layers of technological elements may solve some inherent tensions in the sector. Inspired by Martin our goal is to model the architecture of a digital university.

4 METHOD

We conducted a qualitative study over a period of one year, focusing on understanding a phenomenon in context (Yin, 2004). Our case study research approach is based on engaged scholarship (Mathiassen 2017) where informants are not only sources of empirical data, but also helpful in constructing narratives and discuss theoretical and practical implications

4.1 Data Collection

We conducted in all 10 interviews; key informants in university administration, deans, IT personnel, academic staff and students. We also observed students using digital resources. Further, we analysed key documents both relating to the establishment of UNIT and to the more technical tasks of constructing the architecture. We also participated in several workshops where interaction between key participants was important. In addition to this we arranged several project meetings both at the management level as well as project level in order to discuss and evaluate our findings.

To include the student view of the digital university, we reviewed the student satisfaction surveys, and conducted a panel session with 40 students at UiO. The student satisfaction surveys showed a consistent status over time, i.e. most students are reasonably satisfied with the digital services. The panel was asked to assess their use of LMS and social media, and we collected both quantitative and qualitative data.

4.2 Data Analysis

Data analysis was conducted in three steps. First, we established a chronology of important events, before we did a thematic analysis to identify key topics. Then we investigated the role of UNIT in digitalization of higher education before we performed a comprehensive analysis for constructing an enterprise model of the digital architecture. Lastly, in the discussion, we propose an answer to our research questions regarding conceptualization and governance of a digital university. We have continually evaluated our model and our proposition with several informants.

Step	Description	Output
1	Identify key events, key objects and key topics	Section 5
2	Investigate the role of UNIT and construct an Enterprise Model of the Digital Architecture	Section 5.1-5.3
3	We propose two contributions responding to our RQ	Section 6

Table 1: Data analysis

5 AN ENTERPRISE ARCHITECTURE FOR HIGHER EDUCATION

Our case is the University of Oslo (UiO), which is the highest rated university of Norway, with 28.000 students and 6.000 employees. Administrative IT and learning platforms are (mostly) centralized, while research applications are decentralized. The IT department USIT (with 300 employees) has a strong reputation, and co-operates with small local IT units at schools and institutes.

The past two decades the university (i.e. the IT dept. USIT) has, together with other Norwegian universities, developed joint solutions that provides an important fundament for the large-scale digitalization efforts. This was taken a step further when in 2017 a new institution was established in Norway, a directorate called UNIT, with the purpose of coordinating the digitalization in higher education.

5.1 UNIT

UNIT was established as a directorate for IT in research and higher education on December 15, 2017. The background was that the Ministry of Education and Research aimed for a more co-ordinated approach to the digitalization of the sector.

The head office is located in Trondheim and UNIT has approximately 200 employees. UNIT is a result of the merger of CERES, BIBSYS but has also been given the responsibility for part of UNINETT's tasks. UNIT's primary task is to manage a common IT strategy, architecture and services for the university and college sector in Norway. UNIT is thus an important body for following up the government's digitalisation policy in order to enable a common administration of digitalization activities, but also a common direction for improving efficiency, improving quality and enabling access to knowledge.

Examples of activities UNIT must take care of are thus

- Coordination of admissions at universities and colleges
- Student administrative systems and services
- Research-based services and digital learning environment services
- Procurement services as well as other services that provide knowledge and contribute to digitalisation

UNIT's action plan targets two key documents, the digitalization strategy for the university and college sector (Norwegian Government 2017A) and the national strategy for the provision and sharing of research data (Norwegian Government 2017B). A central measure aimed at the realization of the objectives in these strategic documents is the establishment of six committees. These committees consist of professionals from a number of key institutions in the sector, and are intended to ensure that the needs and interests of the institutions are taken care of. A digitization board has also been set up consisting of top executives from the sector, and they are to coordinate the trade unions. The six specialist committees that are established deal with education, research, administration, infrastructure, information security and architectural management respectively.

Among the responsibilities was the development of a shared IT architecture, coordination of digital resources in education and research, and to develop and govern the shared administrative systems. The shared services included:

- The central student application system (SO)

- The central student administrative system (FS)
- The national research publication system (Cristin)
- The library system (BibSys)

The initiative was generally well received in the sector, but there were tensions on the financing model (each university was required to pay annually) and on the central versus local governance of digital solutions. The strategy expressed a *subsidiarity principle*: shared services should be centralized, while specific services should remain at local institutions, and local innovation should be encouraged. Also, the need for co-operation with the private sector for new solutions was emphasized.

Seen from the IT departments of the involved universities, a number of architecture issues quickly emerged, such as the need for sector identity management, managing master data, and the need for a shared integration framework. These solutions impinge on the infrastructure of the sector, and will probably emerge as projects in the near future.

5.2 The university as an enterprise architecture

Our analysis resulted in a simple EA model, built on two main sources, the University of Oslo and the UNIT directorate. It is a layered model, constructed on the ("stack") principles of Enterprise Architecture (Martin, 2012). The model also takes into account the context; universities consist of a range of disciplines that have evolved according to local academic and professional needs.

The top layer shows the *business processes*, where the main ones are research and education, dissemination and innovation as well as administration. We have decided to organize the enterprise architecture according to these business processes.

Then, the second layer are the *user services* like research support, education support, application packages like office and web tools. In addition, social media is used at the university today also to provide user services, and finally student management and financial/HR systems are central as part of the administration process.

Further, the third layer includes *local applications*. For instance, researcher in specific groups often develops their own databases and functionality, sometimes very large, associated to local or international (EU) projects. Examples of application in this layer is research apps, VDI and specific Lab and Video systems, as well as CRM that manages the financial and administrative matters.

Layer 4 includes the *shared UiO solutions*, such as statistics, student web services, as well as the Learning Management System (Canvas), the exam system (Inspera) and the administrative systems such as SAP.

Layer 5 contains the UNIT solutions Cristin, SO, FS and BibSys described above. In general, the lower levels of the architecture contain solutions that are shared between institutions.

Layer 6 is about technical integration, including the ID and access component FEIDE. The bottom layer indicates the physical servers and networks, and also research databases such as SIGMA2.

The architecture is created based on two main perspectives. First, it is structured by the overarching business processes, aiming to understand how these are supported by digital resources. Second, it is structured by organisational levels; it does not describe a software architecture, where the message flows logically through the layers. Although the structure is componentized, the main point is not to show the modular structure, but that the architecture can be divided into layers; at the bottom we have national components that meet national requirements, further up we have components that meet local requirements.

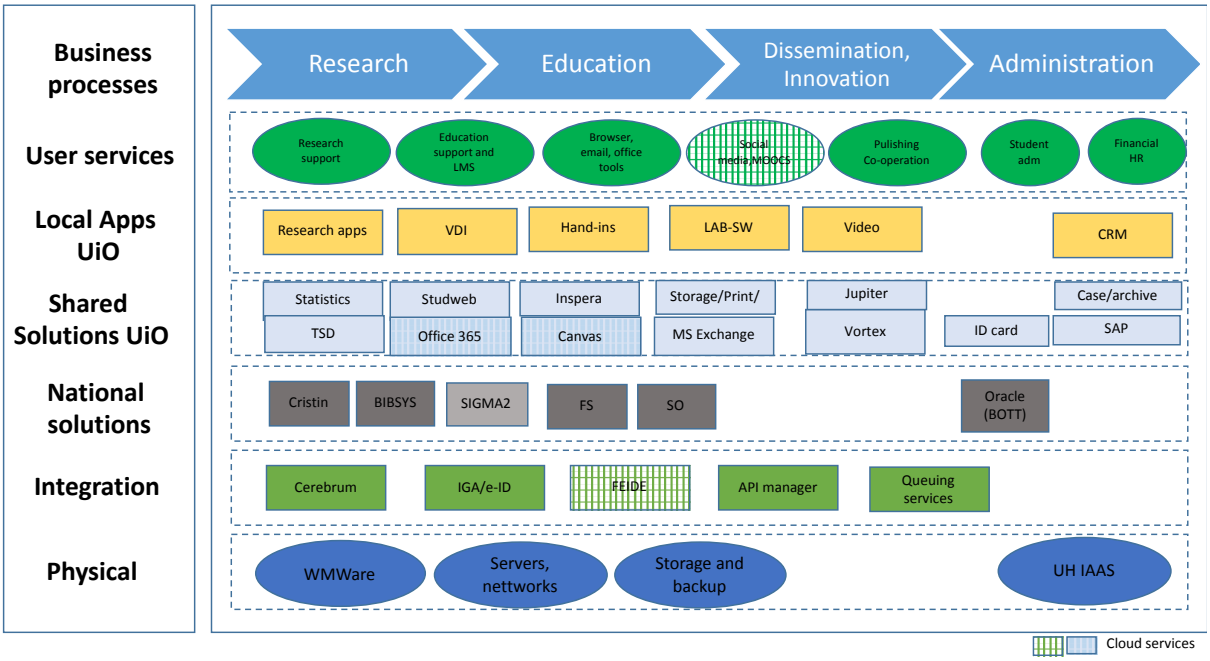

Figure 2: Enterprise architecture for the university

It is clear that cloud solutions (marked with #) increasingly will be deployed, both because of the standardisation in the sector, and because of convenient and possible less expensive technical operations. On the other hand, cloud services imply new integration needs and challenges.

5.3 Competing Ecosystems

The national ecosystem illustrated in the EA model will compete and co-operate with other international and commercial ecosystems. Social media and MOOCS are used by many students, and actors such as Microsoft and Google are entering the field. The strategy of most other universities has been a to pretend that they do not exist.

However, each year new students, with extensive experience with social media, enter the university. They meet a number of digital solutions; university web pages, calendar apps, LMS and, depending on department, local digital resources such a statistics tools, simulation software and so on. The most used tool is probably Google and Wikipedia.

Analysing our data on the students' view, we found that the informatics students use several platforms for communication. Somewhat surprisingly, the students clearly preferred the social media platforms, such as Facebook, Slack and Piazza, rather than using the LMS of the university. When asked why, a typical answer was:

> "We prefer Facebook and Slack because we are used to them. The LMS is more hassle to use than social media, needing much more clicks. Also, we think that the lecturers lack the necessary competence in using the LMS properly. And an LMS can only be used for one purpose, while social media are much more flexible, and work on all platforms."

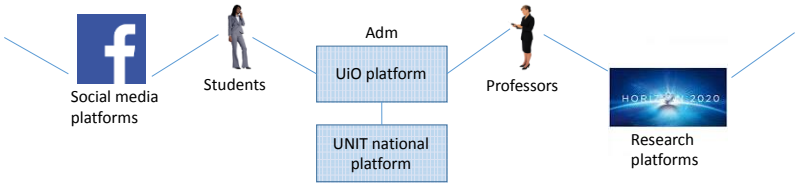

Figure 3: Competing ecosystems

This indicates an underlying tension between the university and students in this issue, because many of the social media platforms use the collected personal data for commercial purposes. This is perceived to be in conflict with the GDPR policy and regulation, which the universities have to comply with. Further developments will depend on the quality of the internal services, and on student choices and habits.

6 DISCUSSION

In this part, we return to our two research questions:

- *How can a digital university be conceptualised and governed?*
- *How should universities relate digitally to the larger national and global ecosystems of higher education and research?*

These questions will be addressed in respectively 6.1 and 6.2.

6.1 Conceptualization and governance

We regard our EA model as a representation of a digital infrastructure. It expresses the key processes and the user services for the key actors. It also shows how the whole portfolio of digital resources supports the value-creating processes. The layered structure unpacks the often opaque digital architecture, and makes is reasonably understandable for people outside the IT professions. The layered model also shows how different resources are orchestrated, such as which services local or central, which systems are national, and which are cloud based. The model makes it easy to see how the national structure can be expanded, and also how for instance Nordic or EU components could be included.

Its strongest point is that it supports a growing digital infrastructure. A successful infrastructure must maintain a balance between stability and change (Wareham et al., 2018). It must provide stable elements (such as platforms), but also allow for local adaptation and innovation of new solutions. As our EA model shows, the layered structure makes this technically feasible.

However, governing this structure is non-trivial. One approach is to centralize as much as possible, while paying lip service to the subsidiarity principle. The key argument is that standardization is the only means to achieve economies of scale, because local solutions, in the long run, are expensive, hard to maintain and integrate, and will not be able to leverage the fast development of technologies. On the other hand, research has shown that innovation by its very nature is local (van de Ven, 2017), and very much so in universities. The *hub-node* solution proposed in the UiO Master (Ludvigsen et al., 2019) plan is an attempt to balance this, but it remains to be seen whether this regime will work. After all, standardization is a strategy whose primary aim is to stop unwanted variation, i.e. innovation.

Traditionally, governance models have built on the organisation structure (Weill and Ross, 2004). We argue that, although this principle is convenient and easy to understand, it fails to address the key issues raised here. The salient point is that it is the *layers* in the digital architecture (as illustrated in our EA model) that should be the premise for governance, because (i) the key governance issues are related to the specific characteristics of each layer, and the interfaces between them, and (ii) using the organization chart as governance structure inevitably leads to silo solutions.

Another salient issue is that universities are decentralized organisations, and generally lack a data-driven process for institutional learning and improvement. This is a hard issue to deal with for all knowledge-based organisations, not only universities; in contrast to factories and mass service organisations, the learning processes of universities are non-linear and emergent. This makes it much more challenging to establish simple feed-back loops, but there are many areas, such as student performance, where this could be effectively used (Siemens et al., 2015).

6.2 Ecosystems

The fast evolution of global platform ecosystems changes the world economy, and may also have large consequences for universities. Most platform ecosystems grow by individual adoption, not by organisational decisions (Parker et al., 2016). It is convenience, not systematic assessment, that makes students choose Slack instead of the local LMS. What is a viable strategy for universities?

In their analysis of platform firms Parker et al. (2016) argue that organisations often will have only two options; either to use their resources to establish their own ecosystem, or to accept being a peripheral part of somebody else's ecosystem. This may be exaggerated for universities at the moment, but it still is a key strategic issue. We discuss this, first in education, then in research.

In education most universities have an uneasy relationship to student's use of social media. Our student panel revealed that some lecturers actively used Facebook and Slack for student communication, while others were absolutely negative. A large survey in Italy (Manca and Ranieri, 2016) showed extensive student use of social media, including systematic use of Facebook and Twitter in academic learning. From the viewpoint of academic staff, it showed ambivalent attitudes; while there are several perceived benefits, the lecturers were concerned about issues such as privacy and the lack of integration with LMS solutions. Manca and Raniere (2016) recommended that universities explore the possibilities of social media to engage students in their well-known environments. Universities are generally sceptic for privacy reasons, but local initiatives abound. It is hard to predict how this will evolve, but a key challenge will be to leverage creative student's contributions to making campus life more rewarding and interesting.

In research researchers have a long tradition in connecting to other digital ecosystem, for instance in EU consortia or in industry collaboration. Participating in innovation clusters and networks includes the establishment of digital infrastructures with a long life-cycle (Rippa and Secundo, 2018). Such solutions are effective in international research networks, but difficult to leverage in a university context.

Summing-up, our findings and analysis indicate that the forces of digitalisation and the institutional logic of universities are congruent in some areas and incongruent in others. Seen as *tools*, digital technologies are generally embraced by students and academic staff. Seen as *infrastructures* (as we have done in this paper) the picture is more mixed. As our EA model shows, a layered perspective allows us to discuss these issues, in particular the balances between stability and change, both in terms of architectures and governance. We argue that a governance regime built on a layered conception of the digital university is a fruitful way forward. What is less clear, is how universities should position themselves in the larger ecosystems.

7 CONCLUSION

In this study from higher education we asked to research questions:

- How can a digital university be conceptualised and governed?
- How should universities relate digitally to the larger national and global ecosystems of higher education and research?

Building on a digital infrastructure approach, we offer two contributions. First, an Enterprise Architecture model, focusing on different layers, provides a useful view on the digital infrastructure of a university. It also indicates how we should think about governance. We believe that the national platform approach ("UNIT") of the Norwegian authorities is one possible way forward in order to obtain scale of economy, and to mitigate the pressures from commercial actors.

Second, we contribute to the discourse on competing ecosystems in the sector. We find that students are enthusiastic users of social media, while academic staff and administrators have ambivalent attitudes; while there are several perceived benefits, there are concerns about privacy and the lack of integration with LMS solutions. Also, it remains to be seen how large Internet actors, such as Google and Microsoft will approach the learning environment.

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