Leading the Digital Transformation (Dx) of Higher Education

Final draft (06/18/2020)

"Digital transformation is not usually about a root-and-branch reimagining of the value proposition or the business model. Rather, it is about both transforming the core using digital tools and discovering and capturing new opportunities enabled by the digital" (Shipilov, 2019).

Executive Summary

Leading the way in the digital transformation of higher education is already a vital part of NC State University's Think and Do mentality. As a land-grant university with a strong tradition of excellence in and commitment to serving as both an economic engine for the state and a catalyst for the development of strong citizens, NC State brings key strengths to the table. For more than 30 years, NC State has invested in digital transformation through, for example, the transformation of the Libraries — recognized as a leading digital/technology library; Distance Education and Learning Technology Applications (DELTA) — recognized for developing innovative strategies for online learning; and investment in technological infrastructure — including technology-equipped classrooms and enterprise architecture such as High-Performance Computing (HPC), a host of technology-enriched educational innovations from departments and colleges, and more.

At the same time, there are numerous external forces that universities like NC State are facing, forces that the recent COVID-19 pandemic has only exacerbated — e.g., increased competition in a period of decreasing enrollments (due to demographic shifts) and reduction in state and federal monetary support for higher education — while raising others, such as how to make a rapid shift in the structure of the student experience, faculty research, and alumni engagement during a time of social distancing. This requires a renewed commitment to developing a vision for the future that is both "high tech and high touch." The challenge is to imagine the future of a public university during a time of disruption. We must also be cognizant of the disruptive forces inherent in digital transformation as evidenced in many industry sectors. We should continually reflect on what NC State might do differently as emerging technologies transition to the mainstream and reshape the educational needs of those whom we serve.

As a forward-thinking higher educational institution, we must consider:

- how we leverage digital transformation in higher education to deliver value to our students and augment our research and innovation practices;
- extending the reach of our university to meet our communities where they are; and

- rethinking internal processes and practices that can benefit from technological advances and ensure the resiliency of our institution.

Underlying much of the discussion in this report is the idea that digital transformation is increasingly about change management. The adoption of, or engagement with, emerging technologies must become part of a broader strategy for organizational change; for moving emerging work from the periphery to the core, and for shifting and reconceptualizing the role of the university. We need to ask ourselves, How can emerging technologies help us reimagine how we connect with and better serve our students and our faculty, reach our communities, and conduct our research? How can we expand and enrich our mission?

Major Themes and Recommendations:

The university's core business is not the transfer of information or even the transfer of knowledge. Rather, **NC State is in the business of developing intellectual capability and capacity that enhances the overall quality of life of students, faculty, and the larger community.**

1. **Academic continuity and agility.** Build academic continuity and agility by leveraging technology to blend multiple teaching and learning modalities — synchronous in-person, synchronous online, and asynchronous online.
    a. *Specific Example:* Require all courses to have an online presence that meets a set of university-wide foundational criteria.
    b. *Specific Example:* Develop baseline equipment and training standards to ensure that faculty, staff, and students have the equipment, training, and support they need to teach, learn and work remotely.
2. **High-tech, high-touch pedagogy.** The digital transformation of higher education requires blended models that combine three elements:
    a. leveraging online learning tools and infrastructure for synchronous and asynchronous core information delivery;
    b. providing high-touch opportunities such as active, situated, and experiential learning, problem-based instruction, entrepreneurship, universal design, student-driven research, and internships; and
    c. the use of emerging and experimental technologies for in-person and online instruction. NC State needs to coordinate across colleges and units to increase both high-tech and high-touch pedagogy that enriches the intellectual lives of our students and builds essential technical skills while also preparing them for a lifetime of workforce, personal, civic, and community prosperity.
        i. *Specific Example:* Develop an interdisciplinary senior-design capstone project that leverages shared, experiential spaces such as the Entrepreneurship Garage.
3. **High-tech, high-touch faculty development.** To perpetuate a pedagogically sound digital footprint across the curriculum, faculty and staff with expertise in incorporating

technology into teaching practices should be readily available to assist other faculty members and instructors to enhance instruction and learning.

   a. *Specific Example:* Develop a cohort of faculty peer advisors to help instructors innovate, adopt, and adapt digital technologies to enhance online learning and expand academic continuity.
   b. *Specific Example:* Develop and share best practices for using high-tech and high-touch pedagogies in conjunction to improve teaching effectiveness and student learning outcomes.

4. **Leading the digital transformation in scholarship and engaged research.** Building digital research infrastructure that supports interdisciplinary research, enhances community engagement and public scholarship, and facilitates technology- and data-intensive research.
   a. *Specific Example:* Develop a central, shared data science and analytics consulting service for researchers from the novice to the expert level that will serve as a competitive advantage for researchers as they seek funding opportunities and refine their research methods.
5. **Fostering critical engagement with and access to emerging technologies for all students.**
   a. *Specific Example:* Provide laboratory environments that incorporate elements of "mega-laboratory" spaces that can interchangeably teach multiple types of science courses on a large scale and that incorporate elements of automation found in state-of-the-art corporate research labs.
   b. *Specific Example:* Extend the reach of virtual, simulated, and immersive learning environments. Such environments need to provide situated learning through experience and enhance problem-based learning. Increase the number of lab offerings enabled by extended reality (XR) environments.
6. **High-tech, high-touch student success that leverages emerging artificial intelligence (AI) and learning analytics systems while paying careful attention to the human elements of student success.**
   a. *Specific Example:* Experiment with artificial intelligence-driven message boards to assist teaching assistants in large courses with repeat questions and improve response times for common student inquiries.
7. **Leading the digital transformation in lifelong learning.**
   a. *Specific Example:* Develop short-form data science certification(s) that can be completed by current students, alumni, and/or employees of partner corporations and organizations.
8. **Digital Extension and Literacy.** By infusing technology outreach and digital extension activities into the Outreach and Engagement enterprise of NC State, the university can become a more effective partner with industry and governments in building critical digital infrastructure and developing fundamental literacies and capabilities to engage that infrastructure.
   a. *Specific Example:* Develop an online degree available to those in rural communities for whom access to Raleigh is an impediment to pursuing an NC

State degree (hybrid with local community colleges or extension offices in rural areas).

b. *Specific Example:* Participating in the coalition of partnerships necessary for developing the network infrastructure/broadband that will be required to sustain robust academic and business continuity.
c. *Specific Example:* Develop or acquire digital literacy / data literacy teaching modules that can be incorporated in courses across the curriculum and shared with community stakeholders via extension channels.

Full Report

Higher education has long been characterized by competing tensions and interests. In a democratic context like the United States, education is regarded as essential for a self-enlightened citizenry, yet there is disagreement over the ends or outcomes of higher education: if it is meant to transform students into moral and cultural agents, whose morals and what culture? If higher education's task is to produce or train economic agents, what is the value of liberal arts, cultural knowledge, and intellectual development? To illustrate the conflict further: higher education has classist roots, yet it can provide social mobility. It can bestow efficient knowledge or training, as well as cultural appreciation. It is associated with universal opportunity and reinforces the notion of the self-made person, but is variable and particular to the institution, and access is linked to and limited by cost and funding. It is necessary for an active public, yet it accommodates (indeed, illuminates and critiques) competing ideologies.

Leading the way in the digital transformation of higher education is already a vital part of the university's Think and Do mentality. As a land-grant university with a strong tradition of excellence in and commitment to serving as both an economic engine for the state and a catalyst for the development of strong citizens, NC State brings key strengths to the table. For more than 30 years, NC State has invested in digital transformation through, for example, the transformation of the Libraries — recognized as a leading digital/technology library; Distance Education and Learning Technology Applications (DELTA) — recognized for developing innovative strategies for online learning; and investment in technological infrastructure — including technology-equipped classrooms and enterprise architecture such as High-Performance Computing, Virtual Computing Lab, and more.

At the same time, there are numerous external forces that universities like NC State are facing, forces that the recent COVID-19 pandemic has only exacerbated — e.g., increased competition in a period of decreasing enrollments (due to demographic shifts), reduction in state and federal monetary support for higher education — while raising others, such as how to make a rapid shift in the structure of the student experience, faculty research, and alumni engagement during a time of social distancing. This requires a renewed commitment to developing a vision for the future that combines both "high tech and high touch." The challenge is to imagine the future of a public university during a time of disruption.

We, as a forward-thinking higher educational institution, must consider how we leverage digital transformation in higher education to deliver value to our students, augment our research and innovation practices, extend the reach of our university to meet our communities where they are, and to rethink internal processes and practices that can benefit from technological advances and ensure the resiliency of our institution. Underlying much of the discussion in this report is the idea that digital transformation is increasingly about change management — that adoption of or engagement with emerging technologies must be part of a broader strategy for organizational change, for moving emerging work from the periphery to the core, and for shifting

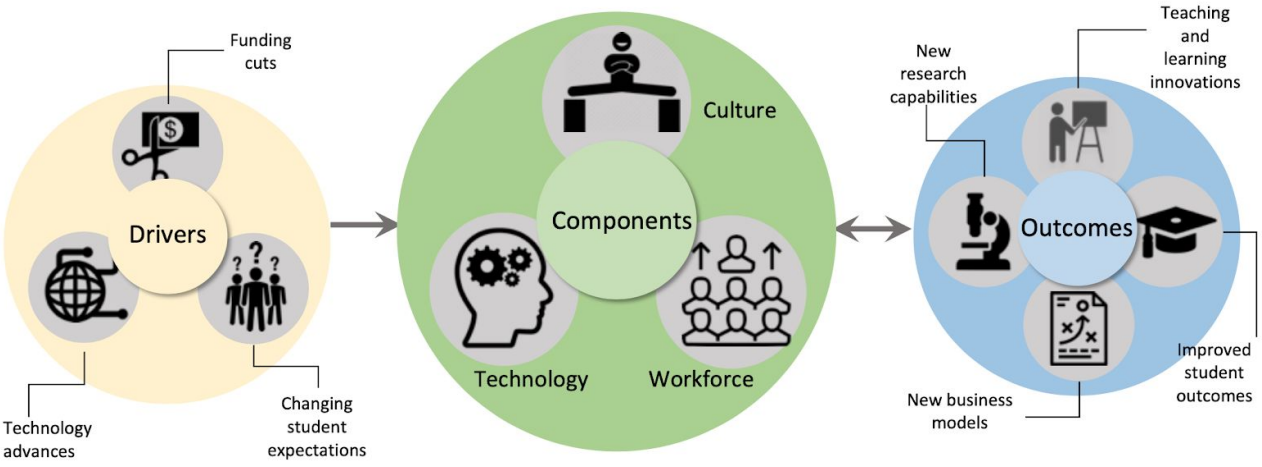
and reconceptualizing the role of the university. We need to ask ourselves, How can emerging technologies help us reimagine how we connect with and better serve our students and our faculty, reach our communities, and conduct our research? How can we expand and enrich our mission? We must also be cognizant of the disruptive forces inherent in digital transformation as evidenced in many industry sectors. We should continually reflect on what we might do differently as emerging technologies transition to the mainstream and reshape the educational needs of those whom we serve.

What is digital transformation?

Simply defined, digital transformation is remapping an "organization's core business to better meet customer needs by leveraging technology and data" (Clark, 2018). Here it is important to reaffirm that the university's core business is not the transfer of information or even the transfer of knowledge but, rather, **the development of intellectual capability and capacity that enhances the overall quality of life of students, faculty, and the larger community.**

EDUCAUSE refers to digital transformation as "Dx," and defines it as a concatenation of "cultural, workforce and technological" changes (Grajek, 2019). Technology alone is not transformation; rather, the EDUCAUSE Dx Task Force (2018) described digital transformation as focusing on the intersection of technology and institutional strategy. In other words, Dx means looking at our "strategy and structure to capture opportunities enabled by digital technology" (Shipilov, 2019). Multiple drivers influence digital transformation, including the pervasiveness of technology in our lives, student expectations, the need to remain competitive, the desire to maximize every expenditure in an era of reduced public funding in higher education, and the necessity of being able to quickly change and adapt (Clark, 2018; Wetzel, 2018). One way to think about this might be to consider how technologies push us to examine more distributed forms of activities that enhance intellectual life over time/space, resources, and expertise.

Figure 1: EDUCAUSE illustration of Dx drivers, components and outcomes (Grajek, 2019).



What are some trends predicted in the higher education space around digital transformation?

- Enabling the extension part of the university mission to reach more people more easily and quickly. Students will have a relationship (beyond alumni donations) with their institutions in a lifelong learning model that blends online and on- campus instruction. Certificates and special offerings are expected to grow (Busta, 2019).
- Data will be mined to understand why some students are more successful than others, and the use of predictive analytics to help identify at-risk students will increase (Busta, 2019; Kelly, 2020).
- In some areas, an increased focus on workforce readiness is expected, with universities providing just-in-time learning skills and partnering with industry to create personalized learning opportunities aligned with student goals and employer needs (Kelly, 2020). In other areas, the need for developing design, creative, and critical thinking capacity to inform innovation across various sectors (i.e., managing environmental change, improving clinical outcomes, enhancing wellbeing) will be demanded and highly valued.
- The use of extended reality (XR) in classrooms to support learning (virtual reality, augmented reality, mixed reality) will become more prevalent (Kelly, 2020). These extended realities can enhance the learning environment by placing the student at an event to create a multi-sensory and reflective experience and allowing the student to study an event from different perspectives.
- The use of artificial intelligence for supporting core instruction and learning (Kelly, 2020) and larger institutional administrative (marketing, recruitment, resource planning) and student support (guidance and warning systems) activities (Zeide, 2019) will increase markedly.
- Digital technologies and transformation will intersect with value/cost propositions. Can technology help us do teaching and learning at scale with reduced costs and higher quality?

- Digital research infrastructure needs in support of large-scale discovery, interdisciplinary and interinstitutional collaboration, and security/compliance will grow (Lynch, 2019).
- Increased need for access to broadband and digital technologies/systems for students, faculty and citizens across the state (NCBIO, 2017).

What will digital transformation require?

- Changes in university business processes.
- Intentional upfit of technology skills (for students, faculty and staff).
- Review and alignment of cyberinfrastructure plans.
- Agile mindsets.

What are some of the challenges to consider?

- Higher educational institutions are slow to respond to change.
- Understanding/envisioning the overall impact is challenging.
- The cost for digital transformation may require significant investment before we see measurable benefits.
- Limited access by the students/learners/communities due to equipment, software, or bandwidth limitations.

How might we imagine a transformed university experience?

- Hybrid or blended approach to recruitment.
- Streamlined application and registration processes.
- Multiple entry online as well as face-to-face learning options across the student's lifetime.
- Credit and non-credit options to enhance student experience, community outreach and workforce readiness.
- Increasing digital footprint in all courses; creating courses that have the ability to shift from face to face to blended to online formats; enhancing face-to-face courses with innovative technologies. Research technologists and digital support platforms and services to help faculty navigate use, share, and retain digital research assets.

What do we need to do?

We need to articulate the value proposition of higher education and how the pervasiveness of technology can help us do what we already do, better. We also need to determine how to achieve our mission by leveraging technologies to do things in new and innovative ways. Finally, we also have to examine the conditions under which digital technologies can serve as enablers, and not isolators. In other words, how do we balance high tech with high touch and personalize learning for our students so as to enhance their intellectual (and by extension their professional and civic) lives? We need to determine how to take advantage of emerging technologies to help us innovate not only in the teaching and learning space, but in bettering our overall business practices (i.e., identifying efficiencies to be had in student affairs and non-academic management via technology), and in conducting and distributing our research.

Major Themes and Ideas:

1. **Academic Continuity and Agility**
   How are we changed by the remote teaching experiment of the spring 2020 semester? How can we take what we learned from this experience and ensure that the university can thrive no matter the circumstance? A series of foundational recommendations emerge from and are given greater urgency from the COVID-19 experience.
   a. All courses will have a yearly updated academic continuity plan on file that leverages the online tools that best align with course goals and learning outcomes.
   b. Determine a technology baseline (infrastructure and competencies) among faculty, instructors and students to enable them to get the most out of blended and remote teaching and learning, including mobile computing with webcam functionality. Any requirement among students would need to be considered in financial aid provision. Instructors/faculty would receive appropriate technology training and would be able to select from a range of supported mobile computing options that reflect a reasonable range of pedagogical approaches/choices.
   c. Wherever possible, the University will favor mobile computing options for both instructors and staff, enabling the ability of employees, whenever possible, to work remotely, with basic technology literacy provided as part of its provision.
   d. Develop a set of key digital literacies in conjunction with the emphasis on critical and creative thinking. Appropriate instruction will be embedded into the curriculum for all undergraduate students (e.g. English 101, Engineering 101).
   e. DELTA and the Colleges of Design and Education will collaborate on a review of the university's approach to Universal Design for Learning and make recommendations for adoption across the various courses of study.
   f. Identify and engage with partners to enhance the provision of broadband across North Carolina to connect the university with its remote staff, students and constituents. By treating broadband as a necessary utility like electricity, it could help mend the rural/urban divide when it comes to equity in access to resources.

2. **High-Tech and High-Touch Pedagogy**
   The digital transformation of higher education requires blended models that combine three elements.
   a. Leveraging online learning tools and infrastructure for synchronous and asynchronous core information and content delivery.
   b. Providing high-touch opportunities such as active, situated, and experiential learning, problem-based instruction, entrepreneurship, universal design, student-driven research, and internships.
   c. The use of emerging and experimental technologies for in-person and

online instruction. Central to this strategy is the recognition that positive affect and engagement forms a virtuous cycle with the cognitive aspects of learning. Highly engaged learning builds knowledge and skills while developing the self-efficacy and desire to continue to engage with future learning opportunities. Technologies inherently have both strengths and weaknesses with regards to supporting this cycle that need to be strategically leveraged.

These blended models enable technology-rich experiences that build essential technical skills while also preparing students for a life-time of workforce, personal, civic, and community prosperity. These technologies allow the expansion of possibilities where and when learning takes place. Thus, formative educational experiences do not have to be confined to the campus and to occur only during typical class periods. The future of education at NC State must address the driving need for communication, collaboration, teamwork, leadership, and interpersonal skills in conjunction with technical skills that individuals, organizations, and communities need in order to thrive. Digital technologies and blended models will facilitate stronger connections to the workforce and the organizations that hire NC State graduates. To those ends, we recommend:

a. Implementation of interdisciplinary senior capstone projects that make use of resources in the Libraries such as virtual reality labs and visualization spaces, the Entrepreneurship Garage, virtual internships, and other platforms/resources still to be developed. Provide incentives for faculty to develop innovative approaches to and capacities for such endeavors.
b. Incentivize the redesign of large introductory courses as blended online/in-person experiential learning classes based on existing models created in partnership with DELTA and the Office of Faculty Development.
c. Embed digital communication literacy into the curriculum for all undergraduate students (e.g., English 101, Engineering 101). This would combine the implementation of enhanced communication instruction for students across all majors in tandem with enhanced technology literacy. Employers, Board of Visitors members, and alumni continue to indicate that highly developed communication skills are essential to success in professional life. They are also essential to an active citizenry.
d. Explore virtual field trips, internships, entrepreneurship, and practicum programs.
e. Provide undergraduate research opportunities with faculty using digital technologies in innovative ways in their research or teaching.
f. Investigate and adopt artificial intelligence (AI) technologies such as intelligent tutoring systems and recommendation engines that scale the expert knowledge of staff, faculty, and instructors so that adaptive support is available whenever and wherever it is needed and appropriate.

3. **High-Tech, High-Touch Faculty Development**

To perpetuate a pedagogically sound digital footprint across the curriculum, staff with the expertise in incorporating technology into teaching practices need to be readily available

to assist faculty and instructors. DELTA has developed ample expertise and provides training, support, and consultations on how to incorporate technology into teaching. Additionally, the Office of Faculty Development provides consultations on teaching and learning strategies and approaches. Finally, there are instructional designers/technologists and faculty members currently working within the colleges — some assigned to particular programs or curricula, and others generally available for the entire department or college. Subject matter experts across these offices and colleges regularly learn from each other and collaborate on best practices, for example, by participating in the NC State University Instructional Design Interest Group (IDIG), facilitated by DELTA staff.

Advancing our ability to digitally transform as an institution may be accomplished with a multi-pronged approach.

a. Increasing our ability to work on multiple course redesigns and course refreshes (hybrid/blended/online courses) by increasing the instructional design and multimedia support staff that could be assigned to work continuously across the curriculum on targeted courses. Engaging faculty and instructors who have demonstrated excellence in these areas could provide more opportunities for a concierge service for course redesign, with DELTA staff coordinating with other colleagues depending on the needs of the project.
b. Offer “teaching with technology” training for all faculty and instructors, to be renewed every five years as appropriate, that would include a laptop and additional peripherals (picking from two or three predetermined/supported possibilities), and that would help ensure that instructors are confident in their abilities to have both the tools and the skills to teach from anywhere.
c. Support with funding and training a network of peer supporters — “teaching buddies" — across the curriculum areas. These faculty or instructors could be funded with stipends similar to Faculty Fellows programs and would be asked to provide a certain level of training/support to their peers as part of this network. Peer support faculty would be required to attend training in the best uses of teaching with technology, and their expertise would be leveraged by their peers.
d. Create faculty “internship programs” to allow them to investigate the latest technologies and practices in industry and other professional, cultural and civic contexts, and to incorporate them into the classroom as appropriate.
e. Better leverage social media technologies and similar technology-augmented social networking tools to give faculty and instructor peer support and mentoring in best practices with regard to the use of instructional technologies.

4. **Leading the Digital Transformation in Scholarship and Engaged Research**
Building digital research infrastructure that supports the changing research and scholarly environment while enhancing community engagement is an essential component of the digital transformation of the university.

NC State's funded research climbed 89% between 2008-2017. For the first time, NC State outstripped UNC and Duke in National Endowment for the Humanities (NEH) funding for Digital Humanities and Public Humanities Projects. The College of Engineering is one of only two in the nation currently leading two National Science Foundation Engineering Research Centers (ASSIST and FREEDM). The Center for Geospatial Analytics in the College of Natural Resources pushes the boundaries of spatial data science to advance discovery and inform real-world decision-making. Faculty in the College of Design have received national industry awards for exceptional design, virtual reality (VR)and architectural projects. In addition, data-driven inquiry is growing in research across disciplines, and large multi-institutional, interdisciplinary research teams are commonplace.

However, the infrastructure needed to effectively support these teams is lacking. How can we effectively share active data sets for real-time collaboration? What systems and expertise are required to integrate and process heterogeneous data? Classic research infrastructure, consisting of core research facilities and HPC clusters, are available to researchers with a baseline level of technical skills, but work remains to define and develop next generation research infrastructure. This infrastructure will include agile information systems as well as a network of expertise and consulting services that keep pace with evolving research practices.

Research data are boundary objects; a single data set may be used in different ways by research teams at multiple institutions. As data sets are themselves becoming an important research output, we must build our capacity to provide data management consulting services that allow data to be securely described, organized, published, and preserved in a way that allows their reuse and ensures their compliance with data access requirements set forth by funding agencies.

David Parry has stated, "Knowledge that is not public is not knowledge." If we expect the public to underwrite the cost of our research, we should be willing to share the fruits of that research with the public. "It is our mission, and our responsibility, to look beyond our own walls to the world beyond, to enlarge the gifts that we have received by passing them on to others." (Fitzpatrick, 2019) Using technology to thoughtfully advance public science, public humanities, and community engaged scholarship efforts at the university can build goodwill and trust with the people of the state.

As a result, the following recommendations should be pursued to enhance the research, scholarship and engagement mission of the university:

a. Develop a coordinated effort to provision advanced cyberinfrastructure and research support services. The growth in data-intensive research requires navigating the web of IT resources, consulting services, data security requirements and funder compliance, a challenge for our researchers. Most

researchers are not data scientists, yet research today increasingly requires a data-centric approach. To write compelling funding proposals, researchers need access to consultants who can help them integrate data science principles into their projects. Developing a data science and analytics consulting service for researchers from a novice to an expert level will serve as a competitive advantage for researchers as they seek funding opportunities and refine their research methods. The Office of Research and Innovation should be engaged to see how the new Research Enterprise Data (RED) system can be extended with advanced AI and data mining technologies. To achieve the ambitions of a growing Research I university, NC State must create institutional alignment for a culture of research support that bridges institutional domains.

b. Develop platforms that enable access and transferability of large scale digital humanities and design projects to make creative digital technology projects and assets available to public audiences. There is not yet a good model (although MIT, Stanford and the University of Minnesota are all working on this) for ensuring quality/rigor, documentation, collection of assets and transference/accessibility. University presses and library special collections models are outmoded and need to be rethought to invent a platform-based model that capitalizes on NC State's technological infrastructure, the library's accessibility and the scholar's/researcher's creative output.
c. Develop flexible policies that will enable collaboration and the sharing of data across institutional boundaries and with community partners/audiences, yet maintain the security and integrity of our data. The Office of Research and Innovation should coordinate conversations among IRB, the Office of Information Technology, legal specialists, and NC State Libraries to coordinate expanded data archiving and sharing capabilities. Universities are placing a growing focus on interdisciplinary and collaborative research. NC State's faculty may have joint appointments with the university and with industry. They may collaborate with colleagues at institutions across the country and across the world. The nature of fieldwork is changing, as researchers increasingly rely on automated capture of massive amounts of data from the field. This is especially true in the social sciences, agriculture and natural resources. A modern research infrastructure must support these increased needs for ubiquitous broadband connectivity, inter-institutional data transport, storage, and access, as well as the ability to integrate, process, and analyze massive data sets.
d. Take steps to ensure research continuity. The interruption in research activity due to COVID-19 over the past few months has provided a lesson in the fragility of our research infrastructure. We are likely to see worldwide disruptions continue for some time as travel restrictions and social distancing guidelines restrict traditional field and lab research and disrupt scholarly communications channels. The transition to online modes of instruction to ensure academic continuity has required compromise, but it has proceeded more or less ubiquitously. The path to research continuity has not been as successful: "some solutions have been

pauses, shutdowns, delays, reprioritization rather than adaptation. We need to collectively envision what a maximally resilient, highly distributed, low-density, and network-based research enterprise might look like. Until we develop that vision we cannot exploit it as a way to enhance resilience in our current enterprise." (CNI, 2020)

5. **Foster Critical Engagement with and Access to Emerging Technologies for All Students**

   In order to enhance their intellectual capacities and capabilities, all students need some critical engagement and access to emerging technologies both in online and in-person learning environments.

   a. Build experimental classrooms, based on faculty input and building on what has worked best in the NC State libraries, that combine a broad range of forward-looking immersive technologies into uniquely equipped spaces that facilitate dynamic teaching and experiential learning. These classrooms can be part demonstration and visualization space, interactive laboratory, teleportation center, and production studio. Combined with emerging technologies, such spaces enable engagement with smart devices, head mounted displays, projection based arrays and real-time interactive audiovisual systems that allow for hands on learning and immediate, informational feedback. Short term or long term use by faculty, students and affiliates is supported by dedicated production staff and multidisciplinary teams from across the university.
   b. Provide laboratory environments that incorporate elements of "mega-laboratory" spaces that can interchangeably teach multiple types of science courses on a large-scale and that include elements of automation found in corporate labs.
   c. Extend the reach of virtual, simulated, and immersive learning environments. Such environments need to provide situated learning by experience and enhance problem-based learning. Increase the number of lab offerings enabled by extended reality (XR) environments. The growth of virtual, simulated, and extended reality learning modules should result in 1) increased academic continuity, 2) enhanced active learning opportunities for technical skill development and mastery, and 3) cognitive engagement and retention that is conducive of reflection and deep engagement.
   d. Develop means of combining social face-to-face experiences with digitally enhanced or enabled experiences to promote civic engagement.
   e. As appropriate, pursue continued reduction in the number of assigned "traditional" commercial textbooks, many of which are costly for students, replacing with open educational resources (OERs) or immersive/extended reality replacements.
   f. Expand technology-rich library spaces, creative spaces, garage, making, and related concepts.
   g. Engage students in comparative work/research/scholarship with various levels/kinds of technology. To this end, engage researchers already actively

involved in advanced learning technologies (e.g., the VR lab in the College of Design, the Center for Educational Informatics in Computer Science) in partnerships with teaching faculty interested in implementing advanced technologies and pursuing funding for this work (e.g., NSF's Improving Undergraduate STEM Education program).

6. **High-Tech, High-Touch Student Success**
   The growth of tools and information systems to assist with tasks such as student advising, attendance taking, and plagiarism detection has been with us for years, and new tools regularly enter the marketplace promising to free instructors from repetitive tasks. Learning analytics tools have emerged that promise to enhance our ability to effectively advise students, while adding value by identifying at risk students who are candidates for individual outreach and support. Some faculty are experimenting with a new generation of tools that use machine learning and artificial intelligence to function as a "Virtual TA," leading and moderating virtual classroom discussions with no human involvement required.

   We must wade carefully into these waters, selecting technologies that promise effective interventions while also protecting the privacy and autonomy of our students and instructors. Nevertheless, new generations of information systems will arise over the next 10-20 years that will drastically shift the ways in which potential students are prepared for higher education through the K-12 school system, how those students are recruited and selected for admission to NC State, how they receive advising services once they are here, and how their work, their participation, and their knowledge attainment are evaluated as they progress through their studies.

   Thus the primary recommendation is the careful evaluation of emerging systems and technologies that enhance the student experience while preserving academic freedom. Particularly important dimensions of assessment of these technologies include:
   - What data is being harvested and how information harvesting aligns with risk assessment and security guidelines established by IRB, FERPA, and other related state and federal agencies.
   - The cost in storage, programming and manual tagging required to manage this data.
   - The reliability of analysis by the system against the risk of Type I and Type II errors (i.e., false positives and false negatives). For example, the risk equation is very different if the system is being used to provide hints on a homework assignment as opposed to part of the calculation of a final grade in a course.
   - The impact on both the affective and cognitive outcomes of learners. Does the system result in significantly improved outcomes for students, particularly those populations who have historically been academically at risk?
   - How does the system shift work responsibilities for faculty, instructors, and TAs in the course? Does it allow courses to scale without diminishing the quality of

instruction or quality of life for instructors? Does it allow instructors to engage in high-value interactions with students?

7. **Leading the Digital Transformation in Lifelong Learning**
   The 60-Year Curriculum and Transcripts for Life are two initiatives that have captured the imagination of some. The first is based on the idea that there are six decades wherein the typical individual will contemplate their career(s), from roughly age 15 to age 75. NC State has an opportunity to engage with and provide educational opportunities to potential students, current students, and alumni throughout that period. The integration of digital technologies to provide asynchronous and/or remote learning opportunities as part of the core educational experience will be an important element in developing courses, certifications, modules, etc. that can be used during that extended period. Increased use of digital pedagogy and digital learning certification will enable the university to experiment with ideas such as alumni subscriptions for access to disparate offerings, fee-based discrete certification modules, interoperable learning records and transcripts, etc. We recognize that the Re-envisioning Life-Long Education and Credentialing task force is taking the lead on investigating and making recommendations in this space.

8. **Digital Extension and Literacy**
   The COVID-19 pandemic has laid bare the challenges of digital equity. NC State Outreach and Engagement (extension), framed around 21st-century digital access and literacies, has the potential to advance digital access in transformational ways for the university and the State.

   By infusing technology outreach and digital extension activities into the extension enterprise of NC State, the university can become a partner with industry and governments in building critical digital infrastructure and developing some fundamental literacies and capabilities to engage the infrastructure. Technology can also serve as a powerful tool to promote NC State's research output. When paired with thoughtful community engagement efforts, social networks can enable the university and its researchers to demonstrate the value that publicly funded research and higher education brings to the state. Industry Expansion Solutions (IES), Citizen Science, Digital Humanities for the Public are examples that the university can expand upon. The increased importance of digital technologies in all facets of life, the persistent digital divide among the communities of North Carolina, and NC State's robust extension infrastructure throughout the state, present several opportunities to develop a digital extension model. Those include:
   a. Working with state and local authorities to expand broadband infrastructure and capacity across North Carolina.
   b. Providing foundational digital and data literacy information online and through existing agencies.

c. Providing data resources and tools to support precision agriculture and data-informed agricultural practices.
d. Building citizen science programs across the state that connect to data and visualization literacy, serve as an engine for community engagement, and help recruit students from rural communities.
e. Utilizing existing extension infrastructure to promote community engagement and continue to increase economic impact for industries, companies, and agriculture across the state.

A blended technology-agriculture extension model could foster development of an online degree available to rural communities where access to Raleigh is an impediment to pursuing a degree (hybrid with local community colleges or extension offices in rural areas) from NC State. Leveraging extension and community college partnerships preserves the experiential value of an NC State education while expanding access.

As knowledge is developed into a digital form utilizing newer technology, access to this knowledge must be considered and accessible through multiple methods. Upper age demographics and rural locations may be limited to using older technology. Simpler, secure, and productive ways need to be available to low bandwidth learners to utilize this content.

The Infrastructure of Digital Transition

The success of digital transformation in higher education requires recognition of the broad interconnectivity of processes, pedagogy, research, student experience, and the tools required to provide them. These tools, in the form of our digital and technical infrastructure, must be robust and reliable enough to provide a consistent and equitable digital learning and instructional experience for all members of the campus community. A strategically sound approach to infrastructure as it relates to meaningful digital transformation must include a comprehensive plan for providing a robust infrastructure, equitable access, and a comprehensive system for faculty, staff, and student technology training.

1. Infrastructure

As previously stated, digital transformation can be defined as remapping an “organization's core business to better meet customer needs by leveraging technology and data” (Clark, 2018). Transformation inherently means change, and the IT organization’s ability to recognize and adapt to those changes is determined by its enterprise architecture (EA). “In addition to the need for agility and flexibility in the development process, the literature has also argued for enterprise architecture (EA) being a precondition to successful digital transformation” (Ylinen & Pekkola, 2019).

- The implementation of the trends, themes and big ideas presented in this document will require thoughtful and significant investment in EA in the form of compute, storage, and networking to ensure the bandwidth to facilitate the transfer, and processing capability for increasing amounts of data from ever-increasing numbers and types of devices.
- The concept of data centers will continue to evolve towards private/public cloud hybrid architectures. As we increase our utilization of big data and analytics to improve student outcomes, investment in the effortless access to High-Performance Computing power will be paramount. As Brendan Aldrich states, we must, “rationalize that data and begin to capitalize on it — to make use of it, to help make better decisions, and to help ensure our students are supported as much as possible.” (Delaney, 2019). This data will be the engine behind our AI chatbots and the analytics that drive our decision making for our course and pathway recommendations for students. The transformation of research, the expansion of online, blended, and virtual learning environments, as well as the ability to create a truly lifelong learning commitment to our students all depend on ubiquitous access to information. Big data, visualization, AI, and significant analytics cannot be interwoven into our university processes, research, and services if the “bits” cannot reach the designated customer. A reasoned and intentional investment in EA is the driving engine behind delivering that data quickly, reliably, and securely. That security becomes exponentially more important as larger data sets and more diverse data types become cloud provided and web-accessible.

as the growth of bring your -own device (BYOD) infrastructure will soon become unfettered. enable supportable, scale-up capabilities in the support of learning and administration in our digital future.

2. Equitable Access

With our obvious resource constraints, the university must take a forward-thinking approach to leverage an optimistic shift in rural and residential broadband availability made glaringly inadequate during the COVID-19 crisis. Future planning for an equitable system of access must assess the availability and capabilities of 5G networks and other public broadband accessibility endeavors and what possibilities they provide for technology in academic and research extension services. Connectivity is the first step, but our vision must also address ensuring access to the devices and resources required for true transformation in research and instruction. Resources, either through allocation, private partnership, or a revamped fee structure, must be allotted for the acquisition of increased device inventory and a robust, supportable system for inventory management. With connectivity and devices assured, we must leverage growing remote and cloud architectures through mass virtualization to provide a quality digital learning, working, and research environments regardless of device type or technical specification. With these expansions in the cloud and virtual infrastructure, special consideration must also be made to ensure these advances can provide students with physical impairments or disabilities equitable learning experiences and outcomes, either natively or with compensating controls. Technology infrastructure or services that are exclusionary in design cannot be made a cornerstone of a future-proof digital transition.

3. Technology Training and Usage Guidance

Digital transformation in Higher Education requires the organizational agility to adapt and incorporate new and constantly changing digital and technology tools. This need magnifies the importance of creating and maintaining a core level of digital literacy.

This digital literacy initiative must include all members of the campus community, faculty, staff, students and collaborators. The initiative's success will depend on the degree to which it is championed by campus leadership in both their policies of participation and the resources allocated to on-campus training opportunities, on-demand access to quality professional development and learning materials and student education through single credit hour coursework (ex. E115) or required online modules of digital literacy basics. One of the largest obstacles to digital transition for large, slow responding organizations such as higher education institutions is an inability or unwillingness of institutional members to adapt their processes to the digital age. This can often be fueled simply by fear.— The fear of change caused by the lack of confidence campus community members have in their technical skills or the knowledge of how to do things in a more agile and digitally contemporary way. Institutional technology training and learning efforts, designed to diminish those apprehensions for all levels of the campus membership, will be critical for success in the digital transformation process.

Digital transformation requires a major shift in institutional approach, processes and mindset. Inevitably, once we have determined how the institution should be supporting and educating students, performing instruction, and carrying out research the next question becomes how can

we do that. That answer lies in our technological infrastructure. It is the data centers, HPC clusters, servers, racks, switches, cables, and computers along with technical knowledge of our campus community that will make it possible to execute these plans. It is an exercise in futility to attempt meaningful digital transformation without wholly integrating these EA needs into the planning and execution of our long term digital transformation strategy.

Closing

Higher education exists to enhance intellectual capacities, to facilitate the acquisition of knowledge, to help develop the skills to apply it, and to expand it through basic research. As it has in other domains, the literally exponential (Moore's Law) advances have had and will continue to have a profound impact on the business of higher education; i.e., what we do, how we do it, and the value propositions that make it robust and sustainable.

We in higher education have gradually (and sometimes grudgingly) accepted the incursion of digital transformation in how we do what we do. We're teaching online. We're utilizing digitally driven modeling, simulations, and visualizations to aid in learning. We use email, web portals, spreadsheets and databases to carry out the business of the institution. We've recently learned to use Zoom and other tools to continue to do what we do in the context of social distancing.

While it's clear that digital transformation has clearly changed how we do what we do, we've been less enthusiastic to accept that digital transformation is forcing us in some caseto rethink what we do, and to realize that it is also changing the value proposition of what we do. Education and health care, perhaps due to their deep societal roots stretching back for millenia, have been slow to come to this realization. Can higher education with its very deep roots be fundamentally disrupted by digital advances? The answer is an unqualified yes, as long as we can assume that digital technologies continue to advance exponentially. (If it's hard to imagine, consider the disruptive potential of a virus that spreads exponentially.)

What are the forces of digital transformation that necessitate us to rethink what we do? First, a lot has already happened there. Computer science has evolved from a relatively obscure subdomain of mathematics to a stand alone discipline. Other new disciplines have emerged, such as computer engineering, information sciences, computational chemistry, bioinformatics, digital media, data analytics, etc. Where we seem to have failed is in looking more deeply at what we do, including the value proposition, and how it needs to change in the context of digital transformation. A few thoughts:

- What are the goals of higher education? Fundamentally, the goals are to:
    - Enhance the intellectual lives of our students and help them develop the skills and understanding that they need to:
        i. Live healthy and productive lives.
        ii. Participate positively in the context of society.
        iii. Exercise and develop their intellectual capacity.

    - Expand the world's body of knowledge through basic research, significant scholarship and the exchange of ideas. Digital technology has dramatically reduced the cost of disseminating information to the point that it is essentially free. Even on the research side, there has been tremendous pressure to bypass traditional journals to facilitate and accelerate the diffusion of knowledge. While information and knowledge are not the same thing, it's safe to say that we need to take access out of the equation when determining the value proposition of higher education. With digital transformation, a large community of scholars may not be required to support the mastery of knowledge by students (undergraduates in particular), and the economics of the value proposition will make it difficult to support the second goal of new knowledge creation.
    - Support the betterment of our local and global communities through outreach and extension. This is effectively applied research and knowledge transfer that is core to the mission of land grant universities like NC State. Advancements enabled by digital technologies in core economic sectors such as farming and manufacturing have evolved at a dizzying pace with profound impacts. Foods and durable goods produced better, faster, cheaper through precision farming and manufacturing methods. On the flip side, many traditional jobs have been lost to digitally powered tools and machinery, and many more losses on the horizon as AI-powered automation becomes mainstream. The future of work is being profoundly reshaped by the forces of digital transformation and it will be incumbent on the land grant universities from where these transformational technologies emanated to maximize the benefits while recognizing and dealing with the problematic side effects through revamped models of outreach and extension.
- Are we teaching the right things?
    - We often say that the most important skill to learn is to "learn how to learn." We've gone from a world of scarcity of information to an overabundance of information. How we research a topic has gone from spending days in the library following trails of references to sorting through the millions of hits returned by a Google search. Do we adequately prepare students to recognize the difference between information and misinformation?
    - Digital transformation touches every discipline in increasingly profound ways. Should a base level of digital literacy become a core competency required of every student?
- Are our processes for managing curricula and credentialing sufficiently agile?
    - Digital transformation is accelerating the pace at which bodies of knowledge grow and rapidly transforming the tools that we use apply that knowledge in practice. One often hears the mantra, "The top 5 jobs 10 years from now haven't been invented yet." At the same time, we see many jobs in the information economy moving to obsolescence as a result of digital transformation. Are our processes for establishing, assessing, and modifying curricula sufficiently agile to keep pace? Are our four year degrees the most appropriate units of credentialing to

prepare students for a rapidly changing career landscape? Can we make education more fluid and customizable, and "just in time"? Can we relax the rigid structure of semesters, quarters and seat time and move to more asynchronous models with competency-based credentialing?

- It is possible to make higher education "better, faster, cheaper" through digital transformation without sacrificing, and more to the point, actually enhancing quality?
    - A few years ago, Massively Online Open Courses (MOOCs) threatened to fundamentally disrupt higher education. It didn't play out the way it was hyped in the media, but new models did emerge from the great MOOC experiment that have persisted, the Georgia Tech online computer science master's degree being an example. We must get beyond the fear that "better, faster, cheaper" models for higher education will disrupt and destroy our existing business models. The Georgia Tech program is an existence proof.
- Can we find an appropriate balance between high touch (learning through physical presence and direct interaction) and high tech (learning through digital technologies) where the value proposition is optimized?
    - The answer has to be "yes", and therein lies the challenge. We live in a physical world, and while digital technologies are getting quite good at blurring the lines between physical and virtual reality, they will always remain distinct. How do we leverage the enormous power of digital learning methods without sacrificing the undeniable benefits of physical learning environments and experiences?
    - It's vitally important that we recognize these two approaches to teaching and learning as synergistic, not as competing models. Faculty have often been heard say that "online classes will never be as good as face-to-face instruction." That statement, taken at face value, is hard to argue with and in fact probably true in most instances. However, that's entirely missing the point that when effectively combined, high tech and high touch pedagogies can improve both teaching effectiveness *and* student learning outcomes. It has also been said that "Technology in the classroom is like an amplifier. It makes good teaching better and bad teaching worse."

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