Digital Pillar
Draft Report
May 2021

0.   Preface

To accomplish the overarching goal of building UW into a "best-in-class 21st century land grant university true to its Wyoming roots," four focused goals have been named: make UW more digital, make UW more interdisciplinary, make UW more entrepreneurial, and make UW more inclusive. This report concerns the first of these: making UW more digital.

This report is the result of two months of discussions among the Digital Pillar Team (see Appendix A for membership details) and is intended to serve as the framework for exchange of ideas and discussions among all stakeholders (including students, faculty, staff, community colleges, state agencies and K-12 leadership). The report is intended to explore this pillar and supply initial thoughts for academic planning that will take place during the 2021-22 academic year.

The Charge
The charge to the Digital Pillar Team was to explore programs, infrastructure and organizational structures needed to build out the foundations for research, education, and innovation in digital and computational spaces, pivoting UW to stronger financial sustainability and accelerating its role as an economic development engine.

Initial thoughts about the Digital Pillar were laid out in President Seidel's white paper [2] that provided the following guiding principles:

- To have "becoming more digital" be a major part of UW's overarching goal, the definition of digital must be broad and inclusive. Digital curricula, research and scholarly activities will necessarily be different for various disciplines, and the Digital Pillar needs to support all of these.
- The Digital Pillar concerns (a) modern approaches to computation, data, AI and their applications, (b) the abilities to engage in and use complex digital platforms, and (c) digital delivery of courses and support for research and scholarship across all disciplines.
- Digital, including digital literacies of various types, must be infused throughout the student experience from living-learning communities to senior capstone projects, and opportunities to infuse access for graduate students must be developed.
- A centerpiece of the Digital Pillar is a School of Computing (SoC) that enables the knowledge discovery enterprise across the entire university.
- The Digital Pillar must help develop deep and authentic partnerships with community colleges, communities, businesses, and government organizations to support the building of the workforce across the state.
- The Digital Pillar should support the planned hubs of innovation that are part of the Wyoming Innovation Network that will be anchored at UW, the community college partners, and potentially other organizations across the state.

The charge to the committee included the following short-term goals:
- Build out white papers, proposals, funding source identification, and guiding principles for the Digital Pillar.

A separate report providing a plan for the SoC is under preparation, and some details are provided in Section 3.

Contents

This report identifies and explores in separate sections seven key topics related to the Digital Pillar:
1. The importance of the Digital Pillar
2. Infusing Digital throughout the student experience
3. School of Computing
4. Growing Partnerships with corporations, labs and other universities
5. Enabling Research and Economic Development
6. Partnerships with K-12, Community Colleges, Wyoming State Agencies
7. Infrastructure to support a more digital UW.

Each section supplies a discussion about the topic and poses some recommendations. Associated with each topic are proposed working committees that will be filled by nominations from deans and directors and work with the Digital Pillar Team (see Appendix C for these committees and their charges). These action items are intended to frame future discussions that will inform the forthcoming Academic Plan and help supply critical stakeholder input during implementation of the final recommendations. In particular, the committees' first set of recommendations concern the co-creation of the Digital Pillar and its rollout.

Recommendations

0.1. Expand the membership of the Digital Pillars team to include a broad range of disciplines and their perspectives (see Appendix A for additional members).

0.2. Hold meetings with UW students, faculty, and staff to listen to their thoughts about the Digital Pillar throughout its development and implementation.

0.3. Establish discussions and involvement of relevant state agencies regarding the pillar.

0.4. Identify a team to visit Wyoming's seven community colleges to share ideas, explore concerns, and discuss opportunities regarding the Digital Pillar with students, faculty and administrators.

0.5. Conduct focus group meetings with key stakeholders (higher education entities, K-12, business, state agencies, etc.,) throughout Wyoming focusing on Digital Pillar development.

0.6. Showcase what currently exists in the world of Wyoming "Digital Pillar" services and resources.

Executive Summary

As the Digital Pillar (DP) impacts all of UW programs, students, faculty and staff, and indeed all of Wyoming, this report discusses a broad range of topics. Here we highlight some of most critical conclusions and recommendations.

Disruptive changes demand urgent implementation of the DP

Section 1 describes the disruptive changes in the workforce that our graduates enter that mandate significant changes to UW's curricula. Section 5 describes how research and scholarship need to evolve to keep up with increased use of computing to address grand challenges. Section 7 describes how technology is and will continue to disruptively change operational practices at universities.

UW and the State of Wyoming are well positioned to benefit from these disruptive changes.

Economic development activities, such technologies and companies associated with blockchain and increased use of AI in various companies throughout Wyoming, fit well with DP efforts. Recent and ongoing initiatives such as the SER, the Tier-1 initiative, the Science Initiative and the Trustee's Education Initiative will each be strengthened as well as enhance the DP. UW's efforts to enhance interdisciplinary research through tackling grand challenges can be greatly enhanced by the DP.

The DP will better prepare our students.

A primary driver for UW's goal of becoming more digital is to best serve our students by positioning them to be competitive in the job market and have lifelong learning skills needed for successful careers in today's rapidly changing workforce. Suggestions for needed strategic curricular improvements can be found in Sections 1, 2, 3, and 6. These include First Year Seminar, University Study courses giving a "digital for all" experience to our students, and strategic new certificate programs, minors, and new majors.

The DP will ensure access and inclusivity.

Access and inclusivity for students, faculty and disciplines must be a central tenet of the digital pillar. As technology advances at and increasing rate, there will be an increasingly large socio-economic divide between those digitally enabled and those lacking digital abilities. Sections 2 and 4 make UW's Digital Pillar provide access for all its students, and for students in all majors at UW. Technology is advancing so quickly that it is difficult for faculty and staff to keep up to date so that they can incorporate it in their classes, their research and scholarship, and in their service roles at UW. Recommendations for enabling faculty, staff, departments, and units to become more digital are also made in Sections 2–4.

The DP will enhance research/scholarship and better serve Wyoming.

Becoming more digital should improve the ways UW faculty teach and UW students learn, supporting faculty and students in all disciplines as they explore the frontiers of scholarship, creative activity, and the complexities of an interdependent world. Section 5 provides a glimpse

of the breadth of research enabled by the DP with discussion of possible impacts in Humanities, Health Sciences, Atmospheric Sciences, and Engineering. Digital can enhance the ways that UW serves the State of Wyoming in all aspects: K-14 education, economic and workforce development, and enabling innovation. Sections 4-6 make recommendations regarding these.

A proposed Wyoming Data Hub will be transformative.
A data hub and the associated curricular elements will make Wyoming-centric data readily available for students, faculty, policy makers, citizens, and UW units such as the Registrar, Dean of Students, and OIA to use to better understand problems and issues of interest to them. The Wyoming Data Hub and the supporting expertise will enable UW to make better data-driven decisions in virtually every area of its operations.

A School of Computing will serve as a hub for education, research, and innovation.
Critical to the digital effort is a School of Computing (SoC) that will, in partnership with existing UW and community college units, position our land grant institution as

- A national leader in computational research, education, and engagement, providing academic excellence in teaching, intellectual distinction in research, and transformative innovation for entrepreneurship. The SoC will **champion interdisciplinarity** across campus by fusing computation, digital, and data science curricula with all domains.
- A computational hub for students, faculty, staff, community and our state, industrial and academic partners. The SoC will skillfully l**everage corporate and knowledge partnerships** to unite learners, educators, entrepreneurs, and stakeholders, and create a sustainable robust digital ecosystem.
- A steward, supporter, and developer of digital skills/literacy and computational thinking for all. The SoC purpose is to **nurture computing curiosity across disciplines and backgrounds**, to enhance interdisciplinarity, and to capitalize upon emerging innovations for teaching, research, and economic diversification.

The DP and the SoC will catalyze stronger partnerships.
The DP will maximize Wyoming's investment in and partnership with NCAR through the NCAR Wyoming Supercomputing Center. Additionally, the vision for the DP is already help foster partnerships with other national labs and with corporations which should result in enhanced educational and career opportunities for our students, joint research projects for faculty, and technological innovations. See section 4 for more details on the development of these types of partnerships. The Wyoming Innovation Network (WIN) will be used to enhance the impact and reach of UW's existing K-12 outreach efforts in the digital/computing areas (see Section 6).

The DP will enhance how UW runs it day-to-day operations.
Becoming more digital will require enhancements to UW's infrastructure, and development of expertise. Additionally, indications are that in coming years technologically advances will significantly change (and improve) how universities operate. Section 7 discusses and makes

recommendations regarding organizational and administrative changes needed to meet these challenges.

Diverse and Digital Roots Driving Innovation
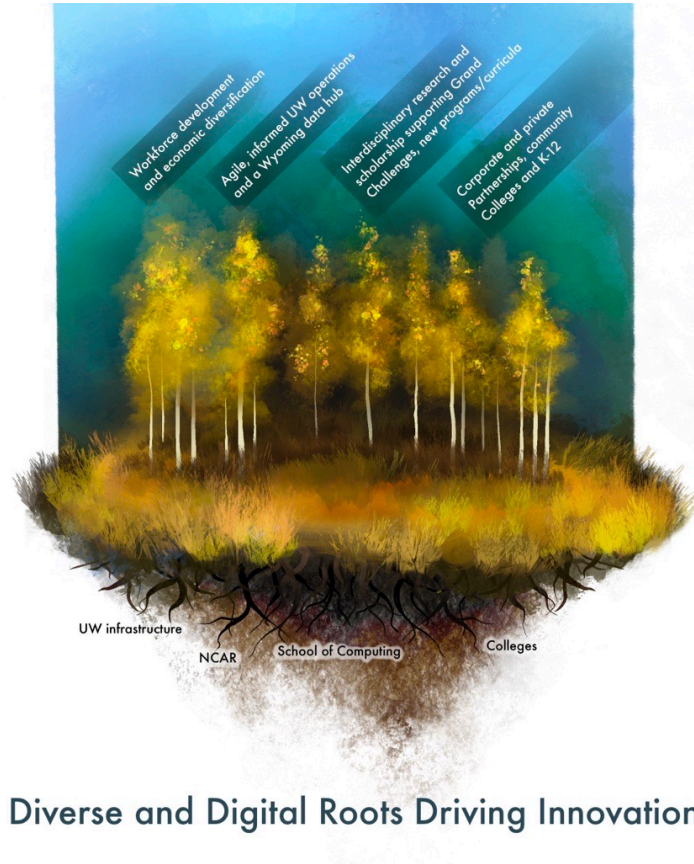
UW's vision of becoming more digital will require the creation and nurturing of a "digital ecosystem" at UW and throughout Wyoming.

Like groves of quaking aspen, the digital ecosystem will share a common root system. This common root system (Wyoming's infrastructure investments (e.g. the WIN, the NWSC, UW, CC, K-12), the School of Computing and UW initiatives (SER, Science initiative, Tier-1 Engineering, and Trustees Education Initiative) will feed, provide the conduit for shared synergies, and ultimately lead to the development of a thriving digital ecosystem.

The ecosystem be drive success in at UW and Wyoming is a diversity of ways including:
- Workforce and economic development
- High-quality educational opportunities for our students
- Interdisciplinary research around grand challenges of importance to Wyoming and the Nation
- Enhanced reputation for UW and opportunities through private and public partnerships that provide new revenue sources for UW.

1. The Importance of the Digital Pillar

"Everyone wants to go digital" [3]. But what does this mean? For some it is the use of applications to enhance their creative endeavors, for others it is the use of models to better design an instrument, and for even others it is about data-driven decisions related problems of commercial or societal importance. Universities, as well as companies, have struggled with establishing a common definition.

Computing is the core of digital. Therefore, computing must be central to making UW more digital. The interdisciplinary nature and its rapid evolution and expansion make it difficult to categorize. Some described computing as follows: Computing includes computer science (the discipline that studies the theory and design of computer systems, algorithms, programming languages, artificial intelligence, operating systems, networking, databases, and software engineering) and includes broader applications such as robotics, human-computer interaction, visualization, the Internet of Things (IoT), language technology, machine learning, and information systems [6].

Digital spans beyond computing. It includes statistical analysis of large datasets, computer animation, 3D modeling and printing, interactions with complex digital platforms, and digital performing and visual art as well as the sociological and humanities-based analysis of an increasingly digital society. Also, at the operational level, "digital should be seen less as a thing and more a way of *doing* things" [3]. Becoming more digital should improve the ways UW faculty teach and UW students learn, supporting faculty and students in all disciplines as they explore the frontiers of scholarship, creative activity, and the complexities of an interdependent world. Digital can enhance the ways that UW serves the State of Wyoming and how UW runs its day-to-day operations.

We propose seven attributes of what being more digital means for UW. Being more digital at UW must:

- Be central to preparing our students to be literate citizens and to enter the workforce with the skills necessary to succeed in the 21st century workforce.
- Have statewide impact through partnerships with community colleges, K-12 schools, and companies to enhance these 21st century skills and capabilities for a broad swath of our state's citizenry.
- Play a critical role in supporting and diversifying Wyoming's economy by providing a savvy workforce capable of using the latest technologies and knowledge, applying them to agency and company problems, and driving innovation.
- Enhance the research and scholarship of faculty and students at UW by enabling more interdisciplinary, data-driven, timely studies of issues important to the state and nation.
- Enable UW to be more effective in its day-to-day operations and in fulfilling UW's mission by enabling processes that allow UW to be agile, fast, and informed.
- Leverage corporate and private partnerships.

- Establish power hubs of innovation throughout Wyoming.

A primary driver for UW's goal of becoming more digital is to best serve our students by positioning them to be competitive in the job market and have lifelong learning skills needed for successful careers in today's rapidly changing workforce. Here we briefly discuss two reports on the need for universities to better prepare students for the workforce. Let us begin with two quotes that provide a better understanding of the workplace confronting our recent graduates, even more so our graduates in coming years.

> The world of work is changing. A broad swath of occupations is at risk for transition or elimination through automation and artificial intelligence, and such risks are highest in highly developed economies like that of the U.S. At the same time, many economies and industries that are losing occupations to automation are already re-purposing existing occupations and creating new jobs [1].

> With the pace of technological change quickening and today's rapidly evolving labor market, it is time to rethink the way that we equip students and adult learners alike with the sort of technology skills that empower them for mobility and independence in the digital age. —Brian Krinock, Senior Vice President, Toyota Motors [5].

To illustrate the increasing scope and the speed of the change, we note that "while today's technology threatens just 5% of occupations with complete automation-driven obsolescence, far more jobs (60%) could have nearly a third (30%) of their work activity automated with the application of already existing technology, dramatically changing the work experience of most occupations" [5].

The chart in Figure 1 projects the percentage change between workers in 2016 and workers in 2030 in using certain types of skills. For example, it is projected that for a typical worker, there will be a 91% increase in the amount of time devoted to advanced IT skills and programming.

Simply put, technology is disrupting virtually every job sector and every part of everyday life, and this disruption requires providing our students with different knowledge, skills and experiences. "The foundational human, digital, and business skills that will be needed in the digitally intensive economy of the future are already in high demand today'' [1]. UW cannot wait to become more digital.

Category	Skill	Hours worked in 2016 (Billion)	Change in hours worked by 2030 (Percent)
Physical and manual skills	General equipment operation and navigation		-24
	General equipment repair and mechanical skills		-9
	Craft and technician skills		-2
	Fine motor skills		-8
	Gross motor skills and strength		-9
	Inspecting and monitoring skills		-20
Basic cognitive skills	Basic literacy, numeracy, and communication		-6
	Basic data input and processing		-19
Higher cognitive skills	Advanced literacy and writing		-10
	Quantitative and statistical skills		-2
	Critical thinking and decision making		17
	Project management		2
	Complex information processing and interpretation		18
	Creativity		40
Social and emotional skills	Advanced communication and negotiation skills		27
	Interpersonal skills and empathy		30
	Leadership and managing others		33
	Entrepreneurship and initiative-taking		33
	Adaptability and continuous learning		24
	Teaching and training others		14
Technological skills	Basic digital skills		69
	Advanced IT skills and programming		91
	Advanced data analysis and mathematical skills		25
	Technology design, engineering, and maintenance		31
	Scientific research and development		28

LOW — HIGH

Tasks dependent on basic digital skills consume more worker time than tasks requiring other types of more advanced digital skills, and this time spent is growing extremely quickly!

Source: Analysis of hours spent by U.S. workers on tasks requiring certain skills, by the McKinsey Global Institute, Skill Shift, May 2018

¹ No Longer Optional: Employer Demand for Digital Skills, Burning Glass, June 2019. ² The Digital Edge: Middle-Skill Workers and Careers, Burning Glass, September 2017
³ What's Tech's Impact on Small Business? Here's What We Found Out, Tim Day, Senior Vice President, Chamber Technology Engagement Center, U.S. Chamber of Commerce, January 18, 2018. ⁴ The McKinsey Global Institute, Skill Shift, May 2018
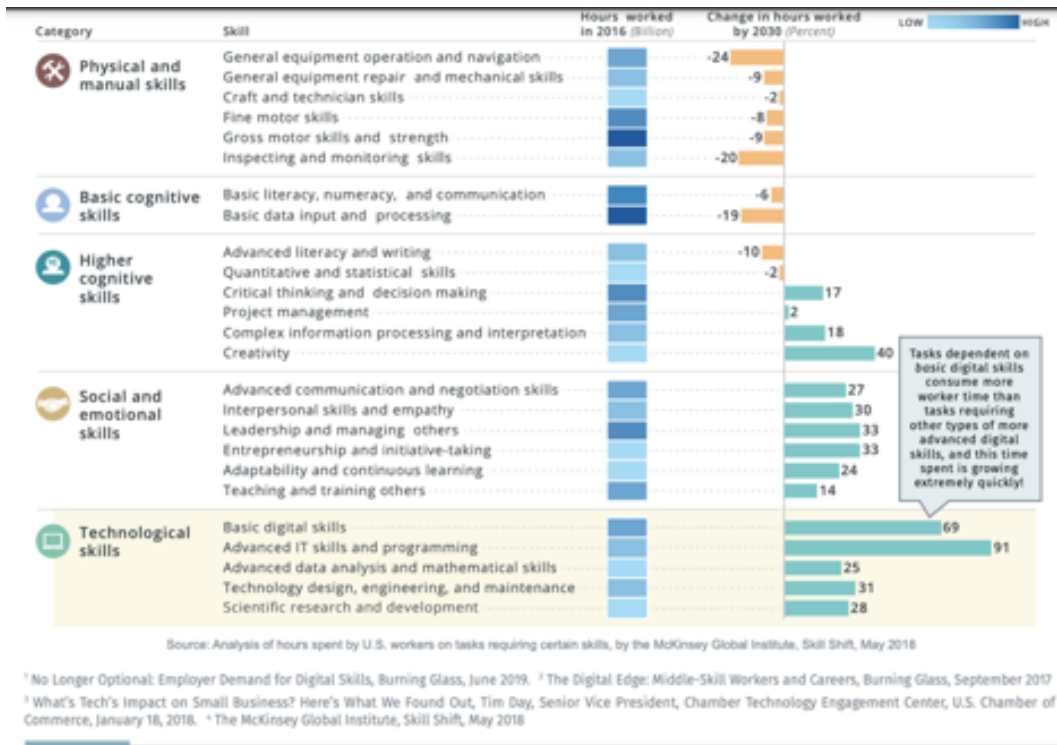
Figure 1

But what are skills that our students need in this new economy both as they enter the workforce, and later in their careers? Fortunately, a report [1] by Burning Glass Technologies commissioned by the Business-Higher Education Forum (BHEF) examines skills in the job market by drawing from a set of more than 150 million unique U.S. job postings dating back to 2007. The research identified 14 skills that have become foundational in the new economy which converge in three interrelated groups: human skills, business skills, and digital skills. These are described in [1] as follows and in Figure 2.

- **Human Skills** apply social, creative and critical intelligence. These skills – critical thinking, creativity, communication, analytical skills, collaboration, and relationship building – appear on many lists of sought-after "soft skills," and are still in high demand across the digitally intensive economy.
- **Digital Skills** are critical to many vocations and are increasingly useful outside traditional digitally intense job families. These skills are especially useful to current or aspiring functional analysts and data-driven decision makers. These skills include analyzing data, managing data, software development, computer programming, and digital security and privacy.
- **Business Skills** play a synthesizing, integrative role in the workplace. These skills allow the other skills to be put to work in practical situations and include project management, business process, communicating data, and digital design.

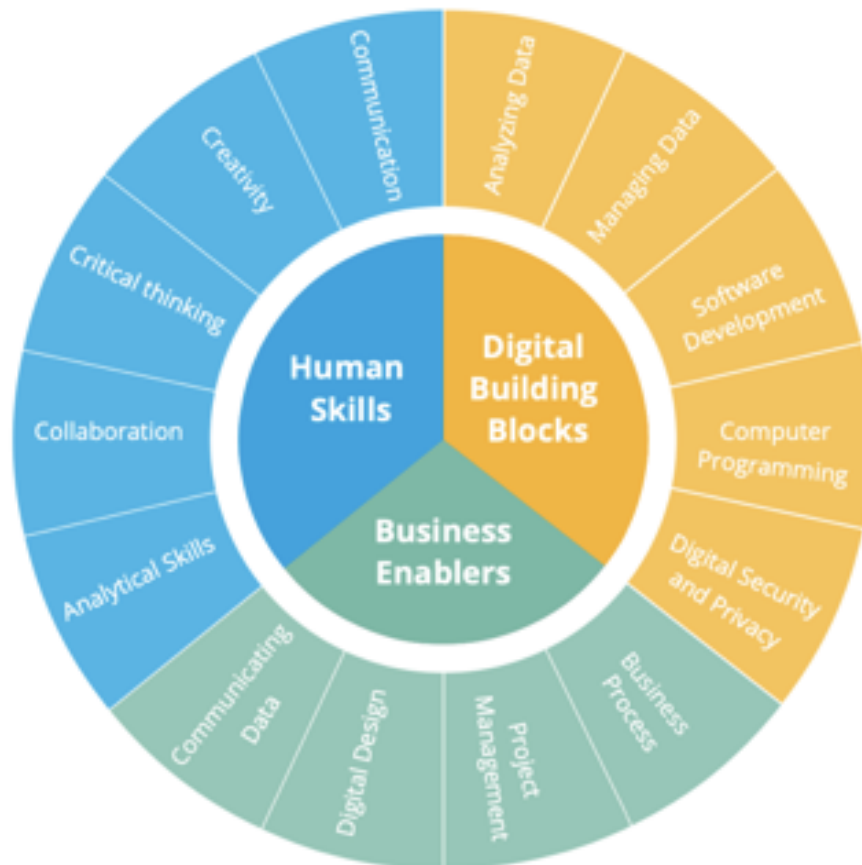## The New Foundational Skills for the Digital Economy

Figure 2

It is worth noting the important roles that human and business skills play. Many of these abilities, such as critical thinking, analytic skills, creativity, communication and collaboration are present in UW's university study requirements and UW majors. More importantly, the workplace that UW graduates enter seeks, and rewards, employees whose skill set spans the pie-chart. It is imperative that UW curricula be informed by these realities, and that curricula utilize faculty expertise in these areas.

Figure 3 shows the growth of jobs in recent years requiring a particular foundational digital skill, as well as the enhanced salaries due to these skills.

Foundation Skill Area	Total Openings: 2017	Growth: 2012-2017	Share of Openings Outside IT and Analysis Job Families	Average Salary Premium
Managing data	3,527,740	24%	29%	14%
Software development	3,326,192	44%	21%	34%
Computer programming	2,571,728	35%	15%	38%
Analyizing data	1,320,678	68%	58%	7%
Digital security & privacy	895,547	75%	28%	17%

Figure 3

As noted in the report, these foundational skills are not unique to technical professions: "they are already sought in the majority of jobs across the economy, regardless of their relation to the digital economy" [1].

The Burning Glass report [1] delves deeply into each of the 14 skill sets of Figure 2. Here, two of the report's deep dives are briefly described. Figures 4 and 5 illustrate the growth in occupations across the economy that require various levels of data-analysis, respectively programming skills. Three things to note:

- These data are over all occupations, not just those that are traditionally thought of as quantitatively intense.
- Not all UW students will graduate with the foundation level of competencies.
- Few UW students currently graduate with the advanced level of competencies.

It is also critical to recognize being more digital necessarily has distinct aspects for different disciplines. As an example, consider various disciplines that have a design component e.g., UW's Visual Arts, Fashion, Interior Design and Mechanical Architecture programs. Digital technologies for creative practice are vital to all the Fine and Performing Arts at every stage and level of the work of creative professionals within the University in music, theatre, dance, and the visual arts. These digital creative practices include, but are not limited to, video and audio recording and editing, music composition, and other digital media. Thus, digital art and design and creative technologies are crucial to a strong digital agenda for the University of Wyoming to remain competitive.

Additionally, digital art and design, and creative technologies are needed for workforce development in Wyoming. Remote work on digital platforms already an option for our graduates has increased due to the pandemic and can be used to foster and maintain creative capital especially that of our graduates wishing to remain in state. Excellent digital degrees, certificates, curricula, resources, tools and outcomes will prove increasingly important in maintaining high levels of artistic performance, exhibition and course dissemination. Central to this is the

acquisition and maintenance of national accreditation for our programs and the success of K-12 Education resident within these programs.

I. Managing Data

Skill spectrum

	Baseline Competencies	Core Competencies	Distinguishing Competencies
Skills	SQL · Managing datasets · Relational databases · Reviewing data quality	Big data · Data warehousing · ETL · NoSQL · Data integration MySQL · Apache hadoop · Data modeling · Data architecture	Data engineering · MapReduce Redis · Distributed computing · Cassandra · PIG · Data lakes / reservoirs

← FOUNDATIONAL
Higher demand / Lower salary

ADVANCED ⟶
Lower demand / Higher salary

Total Openings: 2017	Growth Since 2012 - 2017	Share of Resumes Listing Skill	Average Salary Premium
3,527,740	24%	19%	14%

Figure 4

III. Computer Programming

Skill spectrum

	Baseline Competencies	Core Competencies	Distinguishing Competencies
Skills	JavaScript · Python · Debugging	Java · C / C++ · AngularJS	Multithreaded programming · Domain-specific · Programming languages

← FOUNDATIONAL
Higher demand / Lower salary

ADVANCED ⟶
Lower demand / Higher salary

Total Openings: 2017	Growth Since 2012 - 2017	Share of Resumes Listing Skill	Average Salary Premium
2,571,728	35%	14%	38%

Figure 5

The Burning Glass report [1] ends with the following recommendations:

Higher education must
- Increase the value of its credentials by teaching the skills describe in Figure 2 in all its disciplines and fields.
- Recognize the skills listed in Figure 2 as essential outcomes for 21st century learners.
- Engage faculty and administrators in building the teaching and learning of these skills into coursework and overarching curricular goals. Integrate skills into admissions processes and on-campus student advising.
- Provide capstone learning opportunities to build and document these skills.
- Coordinate with businesses and employers on expectations for classroom and work-based learning, internships, and job skills development.

College students should
- Recognize the importance of these skills to career growth and develop a personal plan to acquire, demonstrate, and signal these skills.
- Value the importance of these skills for landing jobs and advancing careers.
- Build a mindset to become a continuous learner.
- Seek out hands-on opportunities to acquire new foundational skills.
- Signal possession of new foundational skills in one's resume.
- Develop by pursuing volunteer, internship, or work-based opportunities.
- Learn to identify how the foundational skills manifest in new fields.

Recommendation
    1.1. Each department and program at UW should begin discussions about how to provide the students they teach within their undergraduate major with the digital skills and resilience needed for their careers. These discussions should culminate with a plan outlining goals and tangible objectives for making their students more digital.

2. Digital Throughout the Student Experience

As indicated in Section 1, it is imperative for UW to implement ways to provide students of all disciplines opportunities to learn and apply the skills of the digital economy throughout their studies. The digital experience at UW should be a tiered system that includes entry-level course options but also advanced and upper-level courses for specialization. The entry-level courses should establish shared tools for use across campus where appropriate, e.g., by focusing on a single programming language, a single application environment, etc.

Students in every major need to be exposed to the use of complex digital systems or computers to produce products or analyze problems, the use of data to inform decisions, the impact of technology on society, and more. Broadly, this is often referred to as computational thinking.

Additionally, general courses and minors can enhance students' career opportunities and help provide a savvy workforce for Wyoming's companies.

The Digital Pillar will be a central part of UW's Living Learning Communities (LLCs). Students often learn how to use technology best from their peers, and as computing is inherently interdisciplinary the DP is symbiotic with LLCs focused on grand challenges; indeed, basic computing skills learned in the context of a problem that is real to the student can empower the study to see that they can contribute to the resolution of complex problems of interest to them. Innovations resulting from implementation of digital pillar initiatives will empower, equip, and foment associated activities within the LLC.

Recommendations for developing foundational understandings among all undergraduates are the following.

Recommendations
    2.1   Embed digital literacy, appropriate for a student's interests, in the first-year experience, honors, RSOs, and academic programs.
    2.2   Include computing, computational thinking and/or digital analysis as a component of the University Studies Program (USP).
    2.3   Create a "Data Space" to assist students learning how to analyze data computationally. This could be on the model of Studio Coe or the library's Makerspace.

Infusing digital throughout UW means that every student, faculty, and staff member is included in this engagement. This will require supporting faculty/staff to expand their knowledge and experience and in experimenting with new topics and methods in their courses. Many courses offered by IT/ECTL/Libraries exist and should be leveraged and incentivized (perhaps via micro-credentials) for this effort.

Recommendations
    2.4   Support the development and implementation of workshops where experienced teachers in a variety of disciplines can work with faculty to identify where digital spaces exist in their discipline and curricula.
    2.5   Identify and select a digital literacy/competency framework to help guide digital curriculum development, as well as the embedding of digital elements into existing courses.
    2.6   Support trainings and workshops with experts both within and outside of UW who have incorporated digital into their discipline.
    2.7   Find mechanisms to support development and delivery of new digitally infused courses.

There is a tremendous value-added to students learning deeper, specialized concepts; UW needs to provide more such opportunities for students.

Recommendations

    2.8   Encourage departments to develop and implement digitally focused minors to give students more opportunities and to infuse UW with a wider range of digitally oriented courses.

    2.9   Develop programs to use certificates and micro-accreditations to allow delivery of specialized, potentially stacked courses that allow students to explore and gain expertise in a wide range of digital concepts and applications. (See for example the existing ECTL badging, the new interdisciplinary GIST Unmanned Aerial Systems certificate comprised of one- and two-credit course modules, MAP with Wyrkshop, K-12 teacher computer science endorsement and micro-credentials).

    2.10 Provide capstone learning opportunities (and related internships) that leverage and deepen students' computational/digital abilities.

Enabling UW to become more digital will require a concerted effort to expand the digital ecosystem at more advanced levels for certain disciplines. An increasing number of disciplines require students to become savvy with computing in addition to learning the traditional disciplinary knowledge. This can put significant burden on the student and the program. Some programs expect students to gain computer experience on their own or during a class and other programs choose to create and offer their own computing course. These solutions are neither efficient nor effective. To become more digital, UW needs to address how to effectively offer core computing courses so that a richer slate of courses and experiences can be offered to students.

Recommendations

    2.11 Strategically hire to support the Digital Pillar. This should include targeted hires to support core computing areas; joint hires to promote interdisciplinary, digital efforts, and each program emphasizing the importance of developing disciplinary appropriate digital expertise.

    2.12 Co-create and deliver a common set of core computing courses for students in computationally or data heavy disciplines to avoid duplication of efforts and thereby free up teaching responsibilities that could be directed to an enhanced curriculum.

    2.13 Strategically hire to leverage and develop synergetic expertise (e.g., several departments developing expertise in various aspects of Artificial Intelligence or Machine Learning could lead to a rich set of shared courses and interdisciplinary experiences for students). This would entail building off, as well as informing, the expertise at the proposed School of Computing.

    2.14 At the graduate level, research methods in computation should be offered and available for virtually every discipline (as above).

    2.15 Evaluate the feasibility and effectiveness of a boot camp program for entering graduate students that provides them with foundational digital skills needed in graduate school.

Becoming more digital extends beyond the formal curriculum and beyond the UW campus.

Recommendations

2.16 Identify, support and nurture UW experts who can work with the community and illustrate where computing spaces exist in their everyday spaces (e.g., professional developments for teachers).

2.17 Run community events (e.g., through the libraries) that provide informal education about and celebrate UW's Digital Pillar.

2.18 Explore pathways for community members to gain endorsement and certifications relevant to their own professional growth (e.g., K-12 CS Endorsement), (e.g., through tokenizing and micro-credentials).

The Wyoming Data Hub

UW's vision of becoming more digital and increase of digital analysis across all disciplines will require a state-of-the-art repository for data sets both large and small. These storage needs are both short-term (for the length of a project) and long-term, in which data is "published" for future use by other researchers. Large data sets range from management of and access to collections at the Herbarium, the American Heritage Center and the UW Art Museum to ongoing data gathering from the Internet of Things: GIS research, weekly measurements from Snowtel sensors across Wyoming, changing weather data, and astronomical mapping—to say nothing of UW researchers' multiplicity of investigations into biological and ecological information.

One transformative way of infusing digital across the student experience while also enhancing research and providing game-changing abilities to Wyoming agencies and citizens is the creation of a UW Data Hub and the supporting services and curricular offers to enable its use.

The Wyoming Data Hub will provide the digital storage space, management and curation and tools to analyze the data. The hub will make our data-sets available for all, from undergraduate students to research intensive faculty to key units across campus. The Wyoming Data Hub will need to provide storage that is inexpensive, free to students, and capable of significant scaling. For security and data integrity purposes, it will need to be distributed with copies mirrored or backed up in different geographical locations, perhaps at data centers located in one or more of Wyoming's community colleges.

The UW Data Hub will provide the next generation of students and researchers with ever more accessible and more searchable data by and for UW and Wyoming. To bridge the digital divide, tools would be developed for users to more readily massage, plot, and analyze quantitative data. Initial training on how to use the Data Hub could be part of students' first year experience, and as they advanced more in their disciplines, their expertise in leveraging the tools and the dataset in the hub to address problems of interest would be developed in classes in their major.

This hub would perhaps best fit within UW Libraries and could be guided by an Advisory Team, with representation from UW School of Computing, UW Libraries, digital and inclusivity

strategists, and other identified stakeholders. It should grow in concert with campus-wide data gathering and infrastructure initiatives. Goals of this group include advocacy for data standards, and for digital culture change in centralizing and improving access to the data output of the University. This group would build incentives for collaborating with and building programs at Wyoming Community Colleges, including programs for reliable data management and storage. Centralization will increase data reliability, data access reliability, implement FAIR standards for search metadata, and reduce overall cost. A deliverable would be formation of a charge for a Committee on Data Governance, and templates for the University of Wyoming's basic data standards (e.g., for use in grant applications) built into the DMPtool already managed by ARCC.

The Wyoming Data Hub will serve also as the go-to data repository for the Wyoming Innovation Network (WIN). Proposals for external funding now generally require a Data Management Plan, and peer-review publishers and funding agencies require grant generated datasets to become publicly available, including the listing of datasets with DOI in publications. The proposed Wyoming Data Hub can serve as clearinghouse for such data, and researchers should be recognized for their production of externally used datasets.

The accomplishment of this goal will require four elements. First, there needs to be a centralized storage platform, which ARCC could take responsibility for managing, perhaps through expansion of its PetaLibrary or perhaps through a storage project (local and remote) designed specifically for this initiative. Second, a team of two or three dedicated staff (connected with the library, the AHC and IT or ARCC) would manage the storage daily and would look after its integrity, create and maintain proper metadata, provide user services, etc. Third, a data set directory will be needed. While providing easily accessible centralized storage is desirable, many UW data projects already exist elsewhere and more will be created through grants and other activities that require data to be placed elsewhere. Therefore, the Data Hub will need an up-to-date, searchable directory of UW data sets. It will need to be searchable as a stand-alone platform and through Coe Library's Summon search engine. This will enable discovery of data hosted in locations such as the Wyoming Natural Diversity Database, the Water Resource Data System and the Wyoming Geospatial Data Hub. For each data set, the directory will have both general information (conforming to FAIR standards) and a guide to its data structure. Fourth, an advisory committee with representation from the School of Computing, ARCC, AHC, Coe Library, IT and other relevant units will help guide the responsibilities of the Data Hub.

Recommendations
  2.19 Develop a plan to establish and grow a Wyoming Data Hub.
  2.20 Develop trainings and curricula in each discipline that leverage the Wyoming Data Hub.

3. School of Computing[1]

The School of Computing is designed to strategically mesh together existing resources and initiatives, the other pillars (more inclusive, more inter-disciplinary and more entrepreneurial UW's existing strengths in research and teaching, and partnerships throughout UW and across Wyoming, into a system that drives UW to its vision of becoming a best in-class university true to Wyoming's roots.
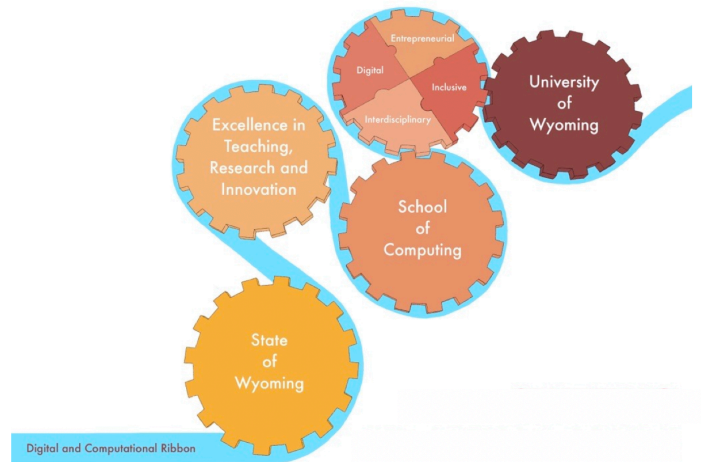
Our vision is to create a unique and inspirational School of Computing (SoC) with national impact and global reach, providing Wyoming and the world with agile and ethical computing professionals, empowered to address societal challenges that are inherently interdisciplinary. Motivated by the roots of Wyoming to live each day with courage, the SoC will enrich our global ubiquitous data-driven society with excellence in teaching, research, and innovative entrepreneurialism. The SoC will produce professionals who are fluent in computing, alongside enhancing its citizens' digital competency.

To this end the School of Computing will, in partnership with existing UW and community college units, position our land grant institution as

- A national leader in computational research, education, and engagement, providing academic excellence in teaching, intellectual distinction in research, and transformative innovation for entrepreneurship. The SoC will **champion interdisciplinarity** across campus by fusing computation, digital, and data science curricula with all domains.
- A computational hub for students, faculty, staff, community and our state, as well as industrial and academic partners. The SoC will skillfully **leverage corporate and knowledge partnerships** to unite learners, educators, entrepreneurs, and stakeholders, and it will create a sustainable robust digital ecosystem.

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[1] Several members of the committee suggested broadening the title to School of Computing and Information as a way to gain wide-spread buy-in across the campus. This should be considered. Here the term School of Computing is intended to by broad see footnote 3 to include information science. We encourage the readers to have this in mind while they go through this report.

- A steward, supporter, and developer of digital skills/literacy and computational thinking for all. The SoC purpose is to **nurture computing curiosity across disciplines and backgrounds**, to enhance interdisciplinarity, and to capitalize upon emerging innovations for teaching, research, and economic diversification.

A School of Computing (SoC) will provide the organizational infrastructure and emphasis to accelerate the growth and impact of computing and data science[2] at UW across research, teaching, entrepreneurship, and engagement. Motivating outcomes for the SoC are to increase UW's ability to address grand challenge problems of critical importance to the state, to better prepare students from diverse backgrounds and in all disciplines for future careers that require computing and data science, to grow the student body in computing and data science, and to support the state in building a new economic sector based in technology through research partnerships, workforce development, training, and entrepreneurship. Finally, an outcome of the SoC is to catalyze excellence in research and teaching to help establish UW as an R1 Carnegie-rated university.

While the vision is for the SoC to be the focal point of computing leadership and activity at UW, the aim is to achieve this by integration and collaboration with a broad set of other units including all academic departments as well as libraries, archives, museums, student success programs and discovery programs. In this manner, the SoC will advance educational and basic research in key fundamental areas of computing and support the adoption and use of computing as a transformational element of research and teaching across the university. For this reason, we suggest the school be simply named the "School of Computing" with the understanding that this will include informatics, broad applications of computing and information systems, computer science, computer engineering, "computing for all", K-12 education, computational sciences, mathematics/statistics, digital arts, and others. Including other topics in the name of the school would inevitably seem to exclude fields.

We suggest a school, rather than a college, envisaging that the SoC needs to be interdisciplinary as well as nimble and flexible, and thus avoid the construction of departmental silos. In addition, as described below, we envisage that by developing SoC as a new school that integrates with

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[2] By "computer science" we refer to the core disciplines concerned with the theory and design of computer systems (e.g., algorithms, programming languages, AI, operating systems, networking, databases, distributed systems, software engineering). By "data science" at a high level we mean drawing on statistics, computer science and applied mathematics to operate on data to achieve meaningful outcomes. By "computer engineering" we refer to the fields that contribute to develop computer hardware and software, focusing on how computer systems work and how they integrate into the larger picture. By "computing" we include computer science, computer engineering, data science and their broader applications across disciplines, and as such envisage a broad interdisciplinary scope. By "information science" we mean an interdisciplinary field of inquiry and professional practice concerned with the collection, organization, sharing, and protection of information, and its relationships with society and individuals across a diverse range of contexts. Closely related, "informatics" broadly describes the study, design, and development of information technology for the good of people, organizations, and society.

existing units via joint appointments; there will not need to be a large body of new faculty with tenure in the school. Finally, starting as a school will provide future flexibility to become a college potentially later. In this direction, the committee noted the way that some Colleges of Computing at other universities are moving towards novel organizational structures as computing becomes more pervasive across all disciplines.

Several thoughtful reports lay out the motivation and rationale for establishing a new school or college of computing (e.g., [7-9]), based on a recognition that computing is different from other departments in science or engineering, that it is pervasive across a university, that it is multidisciplinary requiring potentially broad hiring, that it will increase research and external funding, and that it requires university support at the dean level. In Wyoming, there are additional motivators. The President has included "more digital" as one of the four pillars driving UW over the coming years (and the new SoC will also underpin and support the other pillars: more inclusive, more entrepreneurial, and more interdisciplinary). The whole state is looking to UW to lead in economic opportunities where the technology is a priority. Finally, the new Wyoming Innovation Network (WIN) and the already established Wyoming K-12 Computer Science Hub (WyCS) point to opportunities for Wyoming to lead the nation in a coordinated initiative for workforce development for the rural US.

The School of Computing (SoC) is envisioned to be a statewide asset in which the University of Wyoming and all Wyoming Community Colleges (CC) are academic partners, with SoC partner units at each community college. The SoC will contribute to the new WIN, providing advice and classes for a large statewide audience in additional to enrolled students at the schools. We also envisage SoC partners to include the Agriculture Experimental Stations and Tribal regions. All the partners will expand their digital connections into the SoC, with different emphases. The different CCs have different digital needs and, as the SoC expands its outreach and impact, ranchers and farmers will expand the digital definition further. There is a real need to expand the impact of the SoC into the state government as soon as possible and then target local governments in later phases. This is envisaged to be particularly powerful as a collaboration between SoC and partnering units from across campus. Within 10 years, the SoC should become the entry point for trusted computing expertise in the State of Wyoming.

The SoC should engage in and develop a reputation for world class, high caliber research in areas of computing, recruiting and retaining top faculty and staff. But it must impact the state far beyond a typical research facility. It should develop both undergraduate and graduate level degree programs (e.g., B.S., M.S., and Ph.D.). Minor programs at all levels should be created in collaboration with other departments and programs. Micro-credential offerings for internal and external partners are critical to develop, and those will expand or shrink over time as needs change. These credentialed offerings would serve colleges (e.g., computing, law, or cybersecurity), non-traditional learners (e.g., computing in the 21st century), and critical needs of the state/region (e.g., workforce retraining).

Digital Pillar & Computing Culture

UW Existing Infrastructure

School of Computing
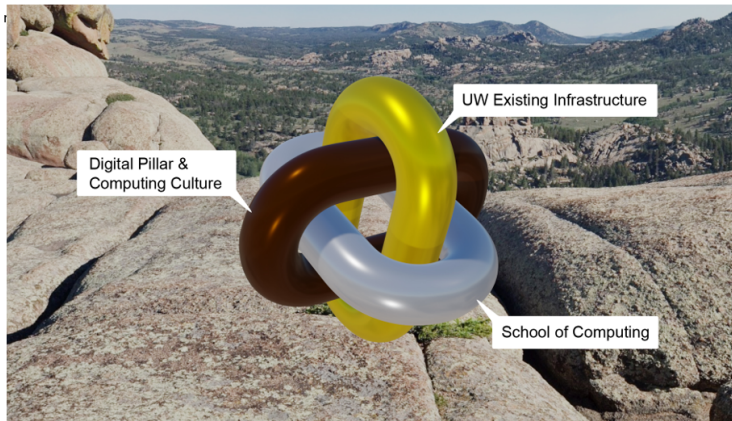
The collaborations between the School of Computing, UW's existing infrastructure and initiatives, and the Digital Pillar are critical to the goal of UW becoming more digital. This is illustrated on the left by Borromean rings. These rings are inseparably linked, yet when any one of them is cut and removed

The SoC could also afford some efficiencies and improvements in UW's computational curricula. For example, having students across UW understand and utilize the same foundational computer platform or programming language (at least through the junior year, before specializing in their field) would enable classes to build off students' basic skill set to explore disciplinary concepts via modelling. Another example is to have common portions (e.g., basics of scientific computing) of courses, taught by various departments taught as a university-wide short course, followed by a disciplinary-specific short course that was experiential or project-based in nature.

The SoC will produce professionals who are fluent in computing alongside enhancing its citizens' digital competency. UW graduates interacting with the SoC via the interdisciplinary initiatives with Departments will benefit from knowledge and experience regarding the application of computing in their chosen domain, equipping them to be perceptive and cognizant graduates who have experience in innovative applications of computing and thus competitive in the workplace. The SoC could lead a statewide program of computing engagement by coordinating publicly facing existing UW offerings, such as Digital Badges (from the Innovation Wyrkshop), Short Courses in 360-degree data capture (in the 3D Viz Center), the Coe Student Innovation Center public activities (in the Coe Library), and the Digital Classes such as Tableau Public Workshops (also in the Library).

For the School of Computing to be successful, a strong Advanced Research Computing Center (ARCC) with a close affiliation with the School of Computing is essential. The ARCC focuses on advanced research computing. With a new Director and updated vision, it should work closely with the Dean of the School of Computing and with faculty researchers to support advanced research computing. It should build on existing resources and NCAR Wyoming Supercomputer Center (NWSC) opportunities and grow ARCC into a unit with research support capacity (both people and facilities) that includes expertise in domains of high strategic interest to the School of Computing, the University, and the state of Wyoming. In turn, the SoC aggregates faculty and researcher needs and opportunities for research infrastructure, providing ARCC with insights and

advice, partnering to pursue funding opportunities to expand and support ARCC's computing infrastructure.

It is imperative that the activities and opportunities provided by the SoC are influenced by state, national, and global needs and are subsequently promoted and made accessible to Wyoming citizens. The SoC should expand on the pandemic-led Zoom experiences of our faculty in 2020 to offer at-home and distance learning opportunities. A needs assessment (of the public and corporate leaders of Wyoming industry) here would allow for specific gaps in the market to be targeted and filled with high impact quality product offerings.

The SoC could lead a program of 'Knowledge Transfer, Exchange, and Partnership'. This would benefit internal and external agencies, as well as the SoC. For example, a UW Department could benefit from training to support a new class, this transfer of knowledge would empower the department to offer a new topic of study. Alternatively, a UW center might seek to collaborate with the SoC to form a mutually beneficial relationship with both parties bringing complimentary knowledge and expertise, as well as skillsets and visionary thought, collaborative research grants could be sought using existing (and new) research computing infrastructure, this would constitute a knowledge exchange. Finally, a knowledge partnership could take the form of swapping individuals in positions of employment, such as a research scientist in the SoC and a software engineer in Google; this could be led partly by the Corporate Partnership strategy.

In summary, the opportunities are well defined, the need is great, and the time is right for a School of Computing at UW. Failing to move forward will jeopardize the career preparedness and career opportunities of our students and, ultimately the economic and social welfare of our citizens. The SoC will champion the broader efforts aimed at making UW more digital through partnerships throughout UW and the State.

The vision of the SoC is ambitious. Through the SoC, (and each of the other pillars), UW envisions forging new trails that will enable UW to become **a national leader in research, education and engagement.**

The SoC will be a hub of innovation and knowledge exchange that will provide UW faculty, students, and Wyoming corporations and citizens, with a backpack of computationally tools to transform their domains.

4. **Enabling Research and Economic Development**

Strengthening UW's Research Enterprise
The Digital Pillar will serve as a nexus that will broaden and deepen many of UW's most impactful research enterprises and will also increase the effectiveness of research and scholarship resources already in place. Examples of such impacts follow.

Consider WyGISC, whose mission is to advance the knowledge and application of geographic information science and technology both on campus and within the state and region. The Digital Pillar's activities will enable integrating WyGISC's innovative online and modular interdisciplinary degree programs and micro-credentials in geospatial data science into the DP's broad digital focus, as well as the Center's outward facing geospatial capacity building in state government and business.

The ongoing EPSCoR Track 1 program has an enormous data science component that, if properly supported during and after the research grant activities, can have an impact on biodiversity and ecosystem science nationally and globally. Improving predictive understanding of biodiversity and ecosystem services response to land use and climate change requires new digital tools and work force training to use those tools. Environmental DNA samples of the entire suite of biodiversity from microbes to plants to animals can now be sampled extensively across space and time. This sampling generates an unprecedented amount of sequence data, which necessitates novel approaches to data storage, serving, and analyses. Moreover, these data become the parameters and test of predictions for understanding how the land surface contributes to the earth system using large scale process models. The EPSCoR-established Data Science Center (DSC) and the faculty and students who enable it to tackle all these problems by collaborating across all areas of campus, the state, and the region. The DSC develops, provides, and trains students, practitioners, and community scientists on digital tools at the forefront of data science and confronting models with data.

An enabling force in all these activities will be the Advanced Research Computing Center. As stated elsewhere, ARCC will be intimately involved in the School of Computing. ARCC's core services will be strengthened with a Digital Pillar emphasis, and those services will be expanded to serve targeted research domains and feathered into the resources offered by the SoC. Importantly, it is services will include enabling access to the NCAR-Wyoming supercomputing center by presenting compute environments on campus that enable code development that can be then plied directly at NCAR.

The research at the Center of Innovation for Flow Through Porous Media (COIFMP) already is ground-breaking in its development of computational models of fluid flow based on the physics at the molecular level that are validated with world-class facilities in the laboratory. The Digital Pillar will afford these research programs carried out at the High Bay Research Facility to access to computational results obtained at much higher rates and the development of models of

unprecedented fidelity to conditions met in the field, benefitting corporate partners while keeping faculty and students at the leading edges of their research domains.

Research conducted on the King Air aircraft platform is on topics of high interest to Wyoming and the Mountain West, and represents a high-profile investment made both by the state and the National Science Foundation. This platform collects atmospheric data from an array of in situ and remote sensors during field campaigns typically sponsored by NSF. One way in which investment in the Digital Pillar will benefit the state and the King Air-executed programs is by creating means for these data to be made publicly available and readily searchable in perpetuity. Data archival and service is a joint UW-NCAR project. In doing so, public appreciation of this class of science and the services UW provides in supporting it will benefit both the campus and Wyoming's citizens who have a stake in the outcome of research that is at the foundation of understanding the water cycle in Wyoming, forest fires and air quality, and more.

The Digital Pillar will have a profound impact on humanities research conducted at the University of Wyoming. Methods of research in the humanities have been irreversibly changed in the digital age. The Wyoming Institute for Humanities Research (WIHR) can become a vehicle on which new ways of teaching and research in the humanities are developed and carried out.

We note WIHR already has many digital programs that reach throughout Wyoming and the world. Immediately when the pandemic began, the humanities institute re-tooled its programming to be 100% digital--the institute was the first, and nearly the only, unit on campus to do so. Therefore, thanks to digital outreach technology, the humanities institute was able to carry the university's public engagement mission, from the spring and summer of 2020 to the present.

A Digital Pillar will enable gaining access to and developing novel uses for the immense information reservoirs that are the collections at the UW Library and the American Heritage Center. What is even meant by digital humanities research is rapidly evolving, and the opportunity presents itself for UW to rise in impact in the realm of the digital humanities by investment and humanities scholar participation in the Digital Pillar. In so doing, the impact of UW humanities students and scholars will rise, ensuring continuing and growing vitality of humanities research at UW.

In the health sciences, the NIH-supported INBRE program is committed to partnership with the community colleges and has in fact already enabled the development of health sciences research infrastructure at all of them. The INBRE program will have research space in the new Science Initiative building, where INBRE faculty, staff, and students will have access to world class facilities. Enabled by the Digital Pillar, communications and data pipelines between the UW and community college campuses will enhance the remote participatory experience of INBRE students of all campuses for research being conducted at any of them, thereby promoting the establishment of new models for health sciences research. Envisioned is the possibility of research programs enabled by strengthened capacity of the Shell 3D Visualization Center (Viz Center) working with INBRE and other programs to advance off-campus teaching and research.

Such a strengthened and networked INBRE program, with exciting new ways of connecting this network of institutions of higher education, will present great added value to the Wyoming Innovation Network (WIN), an initiative aimed at creating a new resource for the state in education, research, and workforce development.

Indeed, within reach through investment in the Digital Pillar is enabling the creation of virtual research environments in the Viz Center that are located anywhere on the globe, including and beyond control rooms at major user research facilities such as are located at U.S. national laboratories. In this way, the Digital Pillar has the promise of yielding a new way for students and faculty to have access to the facilities that will allow them to ask and answer the leading questions of the moment in their areas of expertise.

Importantly, this all leads to the potential of activities promoted by the Digital Pillar to develop new ways of working overall, that enable work to be performed remotely by forming communities connected by digital means to work and research environments. In so doing, Wyoming and rural America can become attractors to corporate partners, enabling new kinds of workforce pipelines to be created that do not require that young citizens, including those of tribal nations, to leave their homes to be at the leading edge of a digital economy.

Creating and strengthening open research and scholarship culture and infrastructure
Over the last few decades, computing has utterly transformed the way research is conducted. The questions that can be posed and the demands that can be placed on the answers were unimaginable just a decade ago. And, of course, computing has similarly been a completely transformative economic force worldwide. Today, there is a revolution of data intensity in everything we do, e.g., self-driving cars, weather monitoring, social media, biometric data, etc. This offers tremendous opportunities for research and economic development, but it also requires significant strategic investments and appropriate organizational structures.

Lack of access to technology and digital-oriented curricula is known to worsen social-economic gaps. Similarly, in today's world, lack of access to computing along with its associated technology and colleagues with computational expertise in many disciplines puts faculty and student researchers at a nearly insurmountable disadvantage. Simply put, research and funding increasingly require computing of some kind. As a land-grant university serving the state of Wyoming, UW offers a broad, comprehensive array of degrees. Compared to other universities, *proportionally little academic research at UW is computationally intensive*. Therefore, it is imperative for UW to become more digital. This pivot will be an important driver for UW-based research and for the State's economic development.

Our digital, connected age has transformed how research and scholarship are conducted, and what it means to be part of a research and scholarship community. An extended, committed institutional effort to catch a national and global wave in open research and scholarship will yield great benefits in facilitating a culture of data sharing and discourse. In facilitating such a culture, an emphasis on being a more digital university, enabled in part by a School of Computing, will

facilitate the goals of promoting interdisciplinarity, inclusivity, and entrepreneurial activity and study.

A highly related description of the nature, implications, and benefits of promoting an open research and scholarship culture at UW is described in the Interdisciplinary Pillar report. There have been in-depth examinations by some agencies, publishers, and research institutions of how to best manage and assess research and scholarship in the open research and scholarship era. The paper [8] outlined several principles of tomorrow's university, and provided the consensus views of researchers, mostly early career, university leaders, funding agencies, and other stakeholders in a workshop funded by NIH and NSF aimed at envisioning the university of the future, considering the emergence of these changes, including how present-day universities can best evolve under the present condition. The authors described a set of 22 principles in six areas: credit and attribution, open scholarship communities, outreach and engagement, education, preservation and reproducibility, and technologies.

The importance of UW being at the leading edge of this transformation is high in general, and in particular with respect to enabling interdisciplinary approaches to research and scholarship to succeed. A small sampling of the conclusions in by Katz *et al*. reveals this relevance regarding the goal of enabling interdisciplinary research to succeed. For example:

"…Institutions should provide appropriate career paths for staff working on open research and maintain the institutional infrastructure required for open research, including recognizing and valuing new, emergent forms of digital outcomes, such as software and data creation, curation and preservation, that are crucial to open research endeavors. These pathways may require rethinking existing classifications and assessments of tenure-track, non-tenure-track, and staff categories of university participants, and funder support for personnel in these categories."

"…Community activities often serve to evaluate, encourage, and improve the use of tools, software, platforms, and data that are critical to open scholarship. All stakeholders must take steps to encourage these communities to develop, such as supporting common standards (and rewarding those who work on them), funding projects that form a "connective tissue" between different communities. They should also actively encourage sharing practices for tools, and people across communities."

"…Every student should be guided to understand and learn how to access and use data and software to be well prepared for diverse, modern career paths.

"…Through open research training, universities should play an active role in increasing research by enabling evidence-based decisions, accelerating discovery, and extending impact to broader communities.

"…The scholarly publication and communication ecosystem should support open and reproducible research and enable credit for these efforts. Universities should encourage

these initiatives by creating incentives (e.g., promotion and tenure categories, service recognition) for such activities."

"…Incentives that promote the public sharing and distribution of scholarly knowledge for open/transparent/ reproducible research practices must be put in place…"

"…Universities should recognize the activities of faculty to educate and train researchers on open and reproducible research skills. Global and national bodies (e.g., National Academies) should promote this recognition across universities."

"…Open-source technologies, tools and platforms provide intrinsic value to researchers and educators and are an effective way of accelerating open scholarship. Academic institutions should favor and encourage open-source solutions as much as possible. "

"…A diverse and interoperable set of tools for open research should be known, shared, and clearly documented."

The university must commit to promoting policies, practices, and technologies that promote open research and scholarship. Importantly, in developing these policies, practices, and infrastructure, *the involvement of junior faculty as well as staff will be critically important, as they are the ones at the leading edge now. Also, the young faculty are the ones who will be most impacted by the actions taken in the near term.*

The interests of Academic Affairs, Research, and Economic Development are keen in this domain. Thus, success of the Digital Pillar in enabling an open research and scholarship culture is vital for the entire educational enterprise at the University of Wyoming.

Advancing a culture of open research and scholarship practices requires a directed, committed effort over an extended period. The actions that follow are closely aligned with those recommended by the Interdisciplinary Pillar group regarding open research and scholarship.

Phase 0 through Phase 1 (Immediate through 12 months) recommendations include the following.

Recommendations

> **4.1** Create an Open Research and Scholarship Committee (ORSC) tasked with performing a review of best practices and generating recommendations regarding open research and scholarship. The committee membership shall come from across the colleges as well as ARCC and Information Technology, as well as new leadership of the School of Computing. It must include junior faculty whose expertise and interest in the outcome of investments in open research and scholarship is keen. ORSC shall be tasked either by the president or by the provost and vice president for research and economic

development. It shall ensure the completion of at least four major tasks, as well as steward follow-up reviews and continuing assessments. These tasks shall include the following:

   a. A review and distillation of best practices for stimulating and rewarding an open research and scholarship culture, including from sources such as Katz *et al.* as well as from discussions with university research leaders at institutions regarded as leading in this domain. Recommendations shall be made to the provost regarding tenure and promotion practices considering the goals of UW becoming a leader in open research and scholarship.
   b. A review and distillation of open research and scholarship practices already in place at UW, conducted by surveying research and scholarship leaders on campus. This shall include a summary of digitally based assets and obstacles as they experience them, and recommendations for strengthening these digital assets, removing obstacles, and building on these practices.
   c. Digital technologies and open research practices can transform the potential of the UW Library, the Rocky Mountain Herbarium, the Vertebrate Museum, American Heritage Center, and other collections to become research instruments with a transformed kind of impact. To promote this transformation, develop a set of recommendations for investments required to promote this transformation, working with the leaders and staffs of these units and drawing upon expertise at other research universities.
   d. Working with the UW Foundation, clarify the potential role of corporate partners in contributing to the development of digitally based and enabled infrastructure that will help enable open research.

4.2 Recommendation of initial policy for inclusion of costs for open research and scholarship infrastructure, both hardware and human resources in state and federal grant proposals.

4.3 Promote alliances with regional research universities, to exchange ideas and experiences regarding open research and scholarship Opportunities for this reside with the Research Data Alliance (https://www.rd-alliance.org) and the West Big Data Innovation Hub.

Phase 1 (12-24 months) recommendations.

Recommendations

4.4. Create a new leadership position, to be supported by grant dollars realized as described above, with the responsibility of driving open research and scholarship infrastructure development. This person's administrative home shall be in the School of Computing.

4.5. Further refinement of policy for inclusion of costs for open resource assets into grant proposals to state and federal agencies.

Other key elements of becoming more digital in ways to enhance research and economic development are listed below, followed by some recommendations. This list is preliminary only. Further input from faculty and students, perhaps through a series or forum on computational research on campus, at national labs, and at other universities will be needed.

The NCAR Wyoming Supercomputer Center

The State and the University of Wyoming have heavily invested in the NCAR Wyoming Supercomputer Center (NWSC) since its inception in 2012. UW is in a strong position to build its computational prowess in research through its access to the NWSC and the related association with UCAR/NCAR. Indeed, Wyoming's share of the NWSC places it in the top 50 universities in the US in terms of computational power. Yet UW is not close to the top 50 US universities in terms of computational research applications in STEM fields.

Wyoming's share of the NWSC resource (1/7th of the total capacity) needs to be better utilized to conduct research of relevance to NCAR, and it needs to be broadened to include different areas of research. The UW-based projects generally address climate and weather research, as well as wind energy, water resources, enhanced oil recovery, and computational fluid dynamics, all fields of research of importance to the economy of Wyoming. The current computer at the NWSC, called Cheyenne, was built mainly for high performance in complex prognostic models associated with such research. The next-generation supercomputer, due to come online in 2022, will get 20 percent of its sustained computing capability from GPUs, which are more effective for artificial intelligence and machine learning techniques because they perform large numbers of computations simultaneously on one accelerator. These new techniques lend themselves to a broader range of research applications such as machine learning, blockchain, biomedical research, and virtually all STEM fields. With the new supercomputer comes a new O(100 Pb) data storage system. UW curates several datasets (see DP section on Data Hub), some of which could be archived and served at the NWSC, rather than in diverse places on campus.

One way to enhance the use of Wyoming's share of this *immediately* is to create a dedicated pre-proposal mechanism for NWSC access that guarantees an allocation of time and storage on the NWSC at the time that a UW grant proposal is written, conditional upon success of the proposal. This should apply to all NWSC-relevant disciplines, for proposals to any federal agency, not just NSF. This pre-approval mechanism strengthens the proposal by tangibly demonstrating that the project has the requisite computational resources. The process will also enable the project to begin research immediately upon the proposal being funded.

While educational projects on the NWSC can be requested and are readily awarded, the supercomputer rarely is used in class projects, especially at the undergraduate level. To lower the access barrier, more can be done to facilitate student access to the facility, e.g., by building easy-to-follow modules to run and analyze simulations in a wide range of STEM fields, such as fluid dynamics, iterative techniques in applied math, etc.

Recommendations

4.6. Work with NCAR/UCAR and NSF to broaden the scope of disciplines eligible to use the NWSC to include all disciplines supported by NSF.

4.7. Create a mechanism to enable UW projects to receive allocations at the time a research proposal is submitted (contingent on the project receiving funding).

4.8. Grow the use of Wyoming's share of the NWSC for educational purposes at graduate and undergraduate levels.

Targeted hiring of faculty

In the longer term, UW must hire simulation and machine-learning focused tenure-track faculty in disciplines relevant to the State and to the mission of the NWSC. Successful simulation and machine-learning focused faculty can drive economic development, not just directly through their externally funded research (bringing in post docs and research scientists), but also, and more importantly, through their computationally focused teaching in their specific disciplines.

Funding these faculty positions in the current economic climate will not be easy. Aside from the normal sources of funding for faculty positions, there may be opportunities for named chairs, based on endowments from new donors and large grants such as the currently pending AI4CI proposal to NSF (Artificial Intelligence Institute for Cyberinfrastructure Innovation Transforming Data-Driven Scientific Discovery) and the NSF EPSCoR Track 1 Research Infrastructure Improvement award. In fact, the 2021 Track 1 proposal, which deals with water availability in Wyoming in a changing climate and the cascading challenges for socio-environmental systems, calls for the creation of a Laboratory for Earth System Modeling at the University of Wyoming. Over the course of 5 years, this proposal aims to recruit a handful of Earth system modelers who will work closely with current faculty to build computational tools and models for Wyoming to be better prepared for changes in water resources in a warming global climate. Joint faculty positions with NCAR have been floated since the NWSC was created but so far have not materialized.

Recommendations

4.8 Hire researchers with expertise in emerging computing areas to enable research and raise funding competitiveness across campus.

4.9 Leverage existing programs (e.g., NSF EPSCoR Track I and Track II programs, NIH INBRE, and the NWSC partnership) to aid in these hires.

Targeted philanthropic support

There are many foundations willing to support disciplinary and interdisciplinary computationally intensive research. For instance, the Paul and Jody Allen Foundation fund climate, ocean, and conservation research through their company Vulcan. The Vulcan Climate Modeling team is using machine learning and advanced software engineering to improve climate prediction and is working in collaboration with NOAA-GFDL to apply machine learning to traditional weather forecasting and earth-system modelling. Similar collaborations and philanthropic opportunities might be open to a Laboratory of Earth System Modelling at UW.

Recommendations

    4.10 The ORED and UW Foundation should develop a plan to enhance faculty's ability to secure foundation funding for computationally intensive research.

    4.11 Develop and implement an aggressive plan to develop corporate partnerships around computing (as has been successfully done at NCSA or Oak Ridge National Labs.)

Economic development opportunities

The decline of Wyoming's extraction industries necessitates a look toward other opportunities for economic development. The Digital Pillar initiative for the University of Wyoming plays well into the new blockchain and digital innovation economy that the state has been moving towards. Wyoming has many advantages for capitalizing on this new opportunity, such as a robust and stable Internet backbone, plentiful electrical power resources, and enabling legislation that creates the ideal circumstances to attract businesses to this new economy. With Wyoming's legislative advances in digital innovation over the last 4 years, companies are beginning to look for ways to capitalize on the legal certainty that Wyoming exclusively offers. UW is uniquely situated to assist in this new economy. For such a new economy to grow and flourish, companies will need a skilled workforce available in Wyoming (provided by UW graduates) and research to support their businesses development (provided by UW faculty and graduate students). UW will additionally benefit from fostering this economy as its graduates will no longer need to seek employment opportunities outside the state, and the enhanced university/business engagement that would be fostered opens new independent sources of revenue for the university. In this way, the Digital Pillar benefits the educational mission, the research mission, and the service mission of the university, as well as providing UW greater and more positive national recognition, enhanced revenue, and new opportunities for future growth.

Growth in computationally intensive faculty expertise matters in today's data-intensive society. The employers of today and tomorrow will seek those applicants more able to read, analyze, and interpret the data. This challenge is not directed just at the Computer Science Department. The revolution is pervasive across STEM fields and even impacts the humanities. The main reason so few employers in any area of information technology have settled their business in Wyoming in recent decades is because of the lack of skilled labor. Enhanced course offerings that include widely applicable computational techniques, such as AI and machine learning, can greatly enhance research and economic development in many disciplines and professions.

Recommendation

    4.11 Create a working group with members from diverse disciplines charged with making UW a computationally intensive research environment to spur economic growth.

5. Growing Partnerships with corporations, laboratories, and other universities.

To achieve the full vision of UW becoming more digital will require strengthening old and developing new partnerships with academic institutions and national labs, as well as with Wyoming and national corporations.

An important first step is to understand the state of existing partnerships and to identify strategically valuable opportunities for new partnerships.

Recommendations

5.1 Perform a campus-wide assessment of corporate partnership experience in the digital realm to identify existing partnerships, best practices, and growth opportunities.

5.2 Survey and assess both experience and impact of existing and past partnerships that have contributed to enhancing UW's digital ecosystem. Review what key performance indicators and metrics have been used in the past to determine success/failure of partnerships and determine what metrics should be used in the future.

A concerted effort to strengthen and grow partnerships will require organizational infrastructure, faculty and staff mentoring, and support.

Recommendations

5.3 Develop a "best practices for partnerships" manual; this can be informed by UW faculty experiences in developing corporate partnerships, including the role of the UW Foundation in the development and support of corporate partnerships.

5.4 Identify broad classes of incentives, including modifications to tenure and promotion practices that may be developed to encourage faculty partnering with universities or industry in research that is of keen economic and fundamental interest.

5.5 Form a university committee to monitor partnership development using established criteria (see Appendix C).

Diversity in types of partnerships should be welcomed. Some should be research oriented, some directly tied to economic development, some to shared infrastructure, some focusing on education. When possible, partnerships should include opportunities for UW students (e.g., internships, externships, company-driven research projects, etc.) Partnerships should be strategically pursued and nurtured.

Recommendations

5.6 Explore partnerships that will help infuse the Digital Pillar into the student experience, support faculty research, teaching, and scholarship, including digital delivery of classes, and provide new capabilities and opportunities for UW. An initial list includes: K-12 and community colleges, regional and mountain west universities (perhaps offering a joint computing graduate program through WICHE); national labs (Argonne National Lab and the Pacific Northwest National Lab have expressed interest), NCAR/UCAR and HPC centers/consortiums, state and federal government, agencies and foundations, international partners, community, industry, national cyberinfrastructure and data projects such as West Big Data Innovation Hub, Scientific Gateways, and the Software Institute).

5.7 Create and maintain a matrix that could track the seedling work effort and the expected or desired short-, medium- and long-term impact of each partnership.

6. Partnerships with K-12, Community Colleges, Wyoming State Agencies

Achieving the goal of UW becoming more digital must be first and foremost be seen as central to preparing students for entering the workforce with the skills they need to succeed in the 21st century world we live in. Further, as the leading institution of higher education in Wyoming, UW needs to work with community colleges, schools, and companies to partner in raising the level of digital awareness, skills, and capabilities across the state.

This section provides an initial draft of a statewide plan to develop appropriate digital and computational skills for Wyoming students K-12 through graduate students. A full development and implementation of the plan will be overseen by a working committee whose charge is outlined in Appendix C.

K-12 Partnerships. The state of Wyoming has been a leader in developing computer science at the K-12 level, and UW has many existing programs that support this effort (e.g., ECE's program for training teachers in computation, CS & CoE joint WyCS Hub). A list of programs, along with brief descriptions and opportunities for growth are provided in Appendix B.

One key program to the Digital Pillar is the Wyoming Innovation Network (WIN). The WIN calls for closer collaboration between the University of Wyoming and the state's community colleges and an emphasis on developing innovative solutions that will support and enhance Wyoming's economy and workforce.

K-12 Partnership recommendations
6.1 Strengthen existing UW programs through deep involvement with UW WIN efforts, collaborative activities between programs, expanded offerings, value-added mechanisms (badges, certificates, other credentials, and micro-credentials, e.g., UW's SOAR program), and corporate partnerships.
6.2 Explore ways [e.g., Special Private Online Courses (SPOCS)] for UW to partner with schools to offer basic computational/digital courses (for credit) to Wyoming high school students.
6.3 Explore the possibility of UW hosting a server that would provide all Wyoming students with access to Jupyter Notebooks[3] and how this could be leveraged to provide every student in Wyoming the experience of using computing/data in their high school classes.

Partnerships to be leveraged for these efforts include: the Wyoming Tribal Council, Wyoming Arts Council, Wyoming Business Council, the Center for Blockchain Initiative, the Wyoming Department of Education (WDE), the Wyoming Library Community, the Wyoming Makerspace

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[3] The Secure Systems Collaborative uwyo.edu/s2c currently hosts several services like this for researchers and WyCS K-12 Hub participants including: https://lambda.ssc.dev/ and http://cocalc.ssc.dev/

Network, the Technology Advisory Council, the Innovation and Entrepreneur Advisory Council and the Wyoming Innovations in Learning Conference

Community College Partnerships
To expand our reach across the state, UW will need to work with community colleges to augment their capacity to train students in computation and data. An example of this is UW's effort regarding software engineering. In late 2020, UW started collaboratively working with Wyoming's seven community colleges, the University of Cardiff, and a consortium of companies to develop a two-year associate degree in software engineering.

Community College Partnerships Recommendations
    6.4   Identify and co-create other digital programs of interest (e.g., game design, internet of things) and added value to Wyoming's community colleges.
    6.5   Through online delivery, and perhaps in partnership with the ECTL, provide activities to train existing faculty at UW to offer appropriate digital/computing courses.

Synergy with Trustees' Education Initiative (TEI)
The DP aligns well several of the TEI priorities.

Priority 1: *Make a strong pedagogical impact on UW CoE students and on Wyoming educators.* As a result of investment through both the CoE and the TEI, several programs are now available to support programs in the college that are digital in nature. These include the following:
- Mursion: a virtual simulation system that provides opportunities for risk-reduced practice on concrete teaching skills.
- Sanford Inspire: a set of online modules that can be embedded in any course or assigned to individual students to support knowledge and skills for educators.
- GoReact: a system for video uploads and feedback that is used by practicum and student teaching supervisors and is embedded in Canvas/WyoCourses.
- ProEthica: a set of online modules focused on ethics in education that can be embedded in courses.
- ATLAS: online video catalog of National Board-Certified Teachers showing best practices.

Beginning in the 19-20 AY, TEI collaborated with the College of Education to create, launch, and execute a multi-year, comprehensive distance course design and delivery project. This project included distance delivery design for BA Elementary Education program and Special Education courses and has expanded to include counseling courses.

TEI is Partnering with the Wallop Civic Engagement K-12 Curriculum Project to deliver a library of virtual resources for K-12 social studies teachers. The TEI/Wallop Team is delivering an online training experience this summer. The training will bring Wyoming K-20 educators together to complete content and standards alignment, and to hone their online course design and delivery skills.

TEI has been awarded a grant by the Wyoming Governor's office to provide digital teaching and learning (DTL) professional development (PD) and resources to Wyoming K-12 educators. These TEI DTL services will include a wide variety of synchronous and asynchronous design and delivery courses, modules, and networking structures. This PD is primarily available to the WY K-12 community via UW WyoLearn, as well as other platforms. Partnership is central to this TEI endeavor, featuring the Wyoming Department of Education, all 48 school districts, and various UW and community college partners.

Priority #2: *Create and disseminate educational knowledge to UW students and Wyoming educators and make a national and international impact on educational research, teaching, and service. Knowledge is created through CoE faculty - and student-led research - "on critical issues of education and human development on which effective educational policies and practices can be supported.*

TEI and the College of Education successfully created and completed the first WYTeach virtual competition. WYTeach provides high-school students the opportunity to practice and demonstrate their professional teaching skills via Mursion augmented reality simulations. The first year's competition included 30+ students from high schools across Wyoming. Research surrounding WYTeach will build understanding of student perceptions of teaching and to improve teacher preparation programs, based on findings.

Priority #3: *The College of Education serves Wyoming through vital partnerships with and for critical stakeholders*. Service through partnership includes the provision of professional development and outreach to/partnership with "...P-12 educational settings, state government, community colleges, and community agencies."

The E4 and E5 Endurance professional development component of TEI, launched in Fall 2020, provides training and resources to the Wyoming education community. The vast and wide-ranging expertise of educators across the state is the foundation of Endurance content and services. Bringing together and expanding access to all of those professionals and their content, for sake of ease, time, and budgets is primarily accomplished through WyoLearn and other technologies.

7. **Infrastructure to Support a more Digital UW**

A robust, flexible and appropriately funded digital infrastructure is the foundation for UW achieving its vision of becoming a best-in-class university true to its Wyoming roots. A well-developed digital infrastructure holds a wealth of benefits. It allows and facilitates the continued transformation and growth of the institution. It not only supports the general operations of the institution but, if well designed, it will be an enabler of innovation, teaching, research, learning and services. A well-developed digital infrastructure includes skilled personnel, cutting-edge networking, computing and security and modern software systems. Similarly, the culture of the institution must be transformed to think and act more digitally. A digital infrastructure needs to

be robust, reliable, scalable and highly efficient. A solid digital infrastructure supports not only the Digital Pillar, but it supports the three other pillars as well.

Higher education is changing and changing quickly. Technology, research opportunities and competition for students are driving some of the changes. Institutions must nurture a culture that not only supports change but proactively seeks the opportunities that come with it. They need to have well-developed teaching, research and learning environments that catalyze innovation. An institution relies on its people and its culture to drive it forward. People are motivated by the culture of an organization. An institution must build an agile and responsive culture. One that is built by a strong, well-communicated vision. By leadership at all levels. By trust and by recognition. Communication channels must be open, efficient, and transparent. The culture needs to be developed to be "Possibility Oriented."

One element in continuing the development of this culture is to appoint a Digital Transformation Team with this as a significant part of the teams' charge. The charge should include a plan of action for "Organizational Digital Evolution" and a plan of listening and communication with UW. The objectives would include ongoing best practices review, new job descriptions that incorporate the agility goals, related metrics, and performance evaluations.

Note: Business models are formed from their digital business strategy and digitization influences the entire business model [11].

To ensure that the Digital Pillar encompasses and brings the UW and wider community along with it, a well thought out program of digital change needs to be defined and implemented. Digital infrastructure touches all aspects of operational, business, research, and client experiences. It is a vastly multifaceted topic that permeates all aspects of a higher education institution. Seeking existing good industry practice here is vital as we define and build our own digital UW infrastructure, true to the roots of Wyoming.

Below we identify, discuss and suggest actions related to four broad topics: personnel infrastructure, current digital services and infrastructure that can be leveraged, and life-cycle replacement, business and management processes.

Recommendations
>   **7.1** Through online delivery, and perhaps in partnership with the ECTL, provide activities to train existing faculty at UW to offer appropriate digital/computing courses.
>
>   **7.2** Work with Human Resources to develop and support more career path options, especially for staff and technical professionals.
>
>   **7.3** Establish robust mentoring/career coaching for staff and technical professionals.
>
>   **7.4** Incorporate remote work options into positions, as appropriate, and use this as a competitive hiring tool.
>
>   **7.5** Explore joint technical professional, research scientist, and faculty positions with other institutions (e.g., NCAR) to enable career growth and knowledge transfer.

7.6 Pool software developers/data scientists and shared staff to assist across UW entities and projects.

Leverage and Further Develop University Current Digital Services and Infrastructure
UW must take a conscientious approach to becoming more digital, both culturally and in building out UW's infrastructure. This will require evaluating infrastructure additions and reorganization to best support and grow innovation, economic development, teaching and learning and research, including to better support grant acquisition. Additionally, a review of UW information structures and processes, to establish what has and what needs to be digitized, will be required.

Recommendations
7.7 Conduct a baseline inventory of existing digital services that includes:
- a stakeholder review of units' and departments' digital needs.
- evaluation of where improvements can be made quickly and inexpensively in information and processes, (e.g., what can and should be digitized?). identification and elimination of processes that cause friction to efficient digital processes.

7.8 Develop the statewide support structure for the Wyoming Innovation Networks.
7.9 Conduct an analysis of how state-of the-art analytics can be better applied in research, operations, and management.
7.10 Consider how AI, AR and VR could be utilized to support all security, research, teaching and learning.
7.11 Continue to build out central IT wireless services, e.g., WIFI 6/7 and Cellular 5G.
7.12 Help create broad access to digital services and digital culture: Partner with communities and others to provide broad wireless services in Laramie, other Wyoming communities and rural Wyoming.
7.13 Continue to improve UW classrooms with digital technologies.
7.14 Develop comprehensive digital infrastructure plans for other units and those not necessarily centrally operated or financed and including determine best organization structures. Consider where synergies might be united, e.g., Libraries; WYGISC; 3D Viz Center, Office of Institutional Analysis; Student Services and First Year Experience (FYE); Distant Services; Digital, Distance and Online Education; Business Operations and Processes; UW Facilities; Human Resources; Center for Blockchain and Digital Innovation; Digital Scholarship Center; Center for Design Thinking; The Ellbogen Center for Teaching and Learning, Coe Student Innovation Center; Advanced Research Computing Center; Academic Technology Services; 4D Visual Art Fabrication Studio, and UW Data Science Center.
7.15 Consider what other organizational structures or subgroups of the above units might be helpful to facilitate UW becoming more digital, more successful and more competitive, e.g., Digital Innovation Enterprise Group, Software Carpentry Group https://software-carpentry.org

Lifecycle Replacement
Becoming more digital will require identifying and earmarking ongoing revenue sources for UW's digital technology, modern software systems and related commitments that require long-term funding. Recommendations for sustainability are given below.

Recommendations

7.16 Include software, hardware and e-resources in baseline inventory; combine or collaborate with infrastructure review of digital services.

7.17 Collect or reference lifecycle planning for current equipment; evaluate existing practices that could be systematized.

7.18 Explore and evaluate current commitments; identify subscriptions or services that can be leveraged more widely or limited to save resources.

7.19 Consider School of Computing opportunities for centralizing parts of UW's digital technology roadmap.

7.20 Identify collaborations for funding and infrastructure development.

Business and Management Processes

Becoming more digital includes improving and streamlining UW's business and management operations. This can be accomplished through strategic new and/or existing platform integrations and upgrades of software applications to ensure a scalable fit-for-purpose infrastructure.

Recommendations

7.21 Identify best practice business and management operations, especially transitioning into digital future models.

7.22 Outline and recognize central structures that can aggregate and report metrics for university operations. Create a plan for transparent reporting to support a positive culture of change towards digital.

7.23 Consider opportunities for working groups to foster a digital culture shift. Aim to open operations to working groups with transparent reporting.

7.24 Seek opportunities to unify platform services that can be streamlined. Continue training and designing processes while considering users and future needs.

7.25 Clarify relationships within UW business structures, identify needs, and support strengths. Create a plan to increase digital practices and use the resources and infrastructure that is being built.

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Appendix A
Digital Pillar Team members

Chairs of Digital Pillar
> Bryan Shader (Professor, Mathematics and Statistics)
> Robert Aylward, (VP Information Technology and CIO)

Members of the Digital Pillar
- Mohammed Ahmed (Associate Professor, Civil and Architectural Engineering)
- Emma Jane Alexander (Shell 3D Visualization Manager)
- Rami Alloush (PhD student, Petroleum Engineering)
- Gabrielle Allen (Special Assistant for Strategic Initiatives)
- Steven Barrett (Associate Vice Provost for Undergraduate Education)
- Mike Borowczak (Assistant Professor, Computer Science)
- Andrea Burrows (College of Education Associate Dean for Undergraduate Programs)
- Craig Douglas (Professor, SER and Mathematics and Statistics)
- Paul Flesher (Professor, Philosophy and Religious Studies)
- Peter Fine (Associate Professor, Graphic Design)
- Ivan Gaetz (Dean, UW Libraries)
- Bart Geerts (Professor, Atmospheric Science)
- Jeff Hamerlinck (Director, WYGiSC)
- Scott Henkel (Associate Professor and Director of WIHR, English)
- Amanda Lehman (Digital Collections Librarian)
- Steve Lupien (Director, Center for Blockchain and Digital Innovation)
- Santosh Madhyanam (Director Financial Planning, ASUW)
- Ibrahim Muddasser, (PhD student, Chemistry)
- Adam Myers (Associate Professor, Physics and Astronomy)
- Suresh Muknahallipatna (Professor, Electrical and Computer Engineering)
- Mohammad Piri (Wyoming Excellence Chair in Petroleum Engineering)
- Mary Catherine Scott (visiting Assistant Professor, UW Honors College)
- Ed Synakowski (VP for Research and Economic Development)
- Neil Theobald (VP for administration)
- Scott Turpen (Professor and Chair, Music)
- Cam Wright (Dean, College of Engineering and Applied Sciences)

Appendix B
Some programs/activities at UW that support the Digital Pillar

WYSTEM - Megan Candelaria

Wyoming Blockchain Efforts – Center for Blockchain and Digital Innovation, Steven Lupien (slupien@uwyo.edu), Director, Blockchain Center of Excellence, College of Business - The UW Center for Blockchain and Digital Innovation features an interdisciplinary approach among UW colleges -- including the College of Business, the College of Engineering and Applied Science, the College of Agriculture and Natural Resources, and the College of Law -- as well as the state's community colleges. The center will focus on fostering innovation; applied research and education; technology development; economic development and job growth; and corporate engagement.

Wyoming Innovation Network - The Wyoming Innovation Network (WIN), calls for closer collaboration between the University of Wyoming and the state's community colleges and an emphasis on developing innovative solutions that will support and enhance Wyoming's economy and workforce. The WIN initiative will have the state's higher education institutions collaborate and develop strategic programming in key areas focused on Wyoming's needs. It includes an emphasis on focusing workforce development on high-potential areas: supporting and training entrepreneurs and new business startups, a research and market analysis agenda aimed at technology transfer and commercialization, and developing outside revenue sources such as corporate partnerships to provide new opportunities for students. WIN is intended to support the state's overall economic vision set forth by the Wyoming Business Council and support education attainment goals developed by the state.
Source: [https://governor.wyo.gov/media/news-releases/2021-news-releases/governor-unveils-higher-education-initiative-with-new-approach]

Wyoming Makerspace Network – Makerspace Coordinator, Tyler Kerr (tkeer1@uwyo.edu) - The Innovation Wyrkshop has long been a place of experimentation and where makers can sharpen these critical STEAM skills. Over the last several years, we have exponentially grown our programming -- offering more and more hands-on learning and technology exposure opportunities to the 6,000 annual makers who call our makerspaces home. With Division of Vocational Rehabilitation partners, we were lucky enough to be provided the opportunity to build five additional spaces from the ground up throughout the state. In total, we have now constructed seven makerspaces across Wyoming, ranging from $35,000 introductory K-12 spaces to multi-million-dollar, world-class facilities. Accordingly, we consider ourselves to be fairly well-versed in what it takes to build and deploy a successful makerspace. Every one of our facilities is a space where people from all walks of life can learn how to tap into incredible emergent technology or make a project they have only ever dreamed of. And every one of our makerspaces is driven by a single fundamental concept: that anyone can be a maker.

UW SOAR Program - Becky Despain, UW ACES, SOAR is a competency-based program at UW made up of experiences that will shape, engage and prepare students to meet unpredictable and complex challenges for the future. As a participant, you will participate in high impact learning experiences in research, cross-cultural and international perspectives, internships, entrepreneurship, leadership and community service.
Source: [http://www.uwyo.edu/soar/index.html].

Wyoming K-12 Teachers Outreach offered by the Department of Electrical and Computer Engineering, Professor Suresh Muknahallipatna, sureshm@uwyo.edu
- Engineering Summer Program for Teachers (ESP4T) - The ESP4T 2021 is a virtual, weeklong professional development workshop focusing on the use of Physical Computing as a teaching tool to engage K-12 students in science, technology, engineering, and mathematics (STEM).
- Machine Learning for High School Teachers (ML4HST) - a new four-day summer program. It is being planned since President Seidel wants our High School students to be aware of Artificial Intelligence as part of the Digital Pillar vision. This year it would be a pilot program with a maximum of 18 teachers in CS, Math, Physics, Chemistry, and Biology areas. The tentative plan is to have the workshop on campus from July 26th thru 29th, right after the two-week-long ESP4T.

WyCS Hub – Wyoming Computer Science Hub offered jointly by the College of Education and the Computer Science Department Professor Andrea C Burrows, Andrea.Burrows@uwyo.edu and Assistant Professor Mike Borowczak, Mike.Borowczak@uwyo.edu.
Details available: http://www.uwyo.edu/wycs
- GenCyber – National Security Agency funded (four years 2018-2021; ~425K) for cybersecurity professional developments and camps for K-12 teachers and students. In 2021, 10 teachers + 40 students.
- WySLICE - National Science Foundation funded (three years 2019-2022; 1M) for 150+ K-8 teachers and state librarians to engage in integrating computer science into existing curricula and activities. In 2021 40 Wyoming educators; 2022 80 Wyoming educators.
- TACoS - MilliporeSigma funded (seven years 2016-2021; ~120K) for week-long upper elementary student experiences with chemistry, art, geology, and computer science.
- Code.org - Code.org & Microsoft philanthropies funded (three years 2019-2021; ~500K) for week-long professional development for K-12 teacher training in fundamentals, discoveries, and principles with graduate student support.
- EiE – School district sponsored Engineering is Elementary (EiE) professional development sessions. Burrows is a certified trainer.
- WySTACK National Science Foundation RET SITE for Computer Science funded (three years 2021-2024; 600K) for high school STEM teacher engagement in emerging computer science research (e.g., AI, machine learning, cybersecurity, AR/VR).

Wyoming Library to Business (WL2B) offered by Laramie County Library System in partnership with University of Wyoming Libraries, the Wyoming State Library, and several economic development partners. Stephen Boss, SBoss@uwyo.edu; Rachael Svoboda, RSvoboda@lclsonline.org

- Public libraries in Wyoming now can apply to host a WL2B station thanks to a #LibrariesBuildBusiness grant from the American Library Association.
- The WL2B Network will be a peer-to-peer group dedicated to assisting Wyoming business communities, encouraging entrepreneurs, and providing reliable, relevant information on Wyoming experts and programs. The WL2B Network is in the planning stages and more information will be available after April 1, 2021.

Appendix C: Recommended Working Committees and Charges

Computational and Digital Thinking for All Working Group

Charge: The University of Wyoming has a responsibility to develop students with a breadth of digital skills and literacy that enable them to excel in the society of today and future of tomorrow. While the needs of individual students, disciplines, and colleges vary, the "Computational and Digital Thinking for All" (C&DT4ALL) working group is charged with:

- identifying, collecting, and synthesizing resources (whitepapers, funding calls, prior reports) related to recent "X for all" attempts (e.g., CS4ALL, CS+X).
- surveying and assessing the current and potential state of computation and digital thinking within the University of Wyoming's 13 colleges, interdisciplinary institutes, and schools.
- defining broad guiding principles and needed resources for tiered/leveled access to "Computation and Digital Thinking" for ALL students, faculty, and staff at the University of Wyoming within five-years *(this WG should collaborate with curriculum WG)*
- identifying specific actions and milestones which the University of Wyoming can utilize and would need in the 2021/2022 academic year to introduce and highlight existing excellence in C&DT within:
  - the entire incoming first-year class (e.g., USP courses/requirements, orientation requirements/activities),
  - current faculty and staff (e.g., courses, trainings)
  - existing departments (e.g., interdisciplinary program reviews/initiatives)

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Computational/Digital Curriculum Working Group[1]

Charge. The Computational/Digital Curriculum has the overall charge to identify curricula spaces and disciplinary content that highlight computational/digital areas across the UW campus and beyond. These computational/digital spaces, which can include (but are not limited to) individual UW colleges and community industries, illuminate potential seedbeds for digital exploration. The computational/digital content that bridges disciplines can include (but is not limited to) data science, software engineering, and online/e-learning, show the need for interdisciplinary, computing-related work with real-world applications.

Questions to study:
- How should the curriculum for the School of Computing (SoC) be organized?
- To what extent do the SoC instructors/affiliates teach new courses and to what extent do they rely on existing courses from academic departments?

- Will every UW student be expected to take some foundational courses related to computing (e.g., a new "digital" USP), and will those courses mostly be taught by SoC affiliates?
- How might the SoC facilitate concentrations, certificates, double majors, etc. in computing?

To achieve a vested interest in this work, DPT team members should reach out to UW colleges and other stakeholders to promote affiliation with a computational/digital curriculum and the SoC that reaches beyond the boundaries of the university.

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Digital Pillar collaboration efforts with K-12, CCs, and the State of Wyoming working group

Charge. This committee will develop a statewide plan to develop appropriate digital and computational skills for Wyoming students K-12 using UW graduate students. These collaborations could include summer camps at local community colleges, including the Wind River tribal college, and their remote campuses; online coding classes and competitions; blockchain mini-courses, and so on.

As part of the charge the committee will:
- develop a basic glossary of related digital and computational terms, conduct a statewide inventory of ongoing efforts to educate different groups on digital and computational skills,
- identify gaps within the inventory, and
- develop a plan to fill the gaps.

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Growing Partnerships working group
Charge. This working group will engage with internal and external stakeholders to solicit ideas and feedback for the digital pillar, leveraging the diverse experiences and backgrounds of our faculty and staff, and matching the digital pillar vision to the broad opportunities and needs of Wyoming and UW. The working group will:

- Identify important UW programs and entities to partner in the growth of the digital pillar (e.g., Research & academic units, museums and libraries, athletics, engagement, maker spaces, NAH, student organizations).
- Survey and assess the experiences and impact of current and past partnerships to contribute to a more digital university, e.g., UW-NCAR, NSF EPSCOR.
- Identify key performance indicators and metrics to quantify and assess the quality and impact of partnerships (e.g., see European Knowledge Transfer Partnerships).

- Identify important external partnerships to cultivate and extend for the digital pillar, and explore opportunities, including common interests and joint strategies. (e.g., K-12 and community colleges, regional and mountain west universities, national labs, NCAR/UCAR and HPC centers/consortiums, state/federal government, agencies & foundations, international partners, community, industry, national CI and data projects such as West Big Data Hub, Scientific Gateways Software Institute).
- Identify the most important existing and new programs, infrastructure, and organizational structures needed to support growing partnerships and collaboration in the digital and computational spaces.
- Identify broad classes of incentives, including modifications to tenure and promotion practices that may be developed to encourage faculty partnering with universities or industry in research that is of keen economic and fundamental interest.
- Explore the most important partnerships to infuse the digital pillar into the student experience, support faculty research, teaching and scholarship including digital delivery of classes, and provide new capabilities and opportunities for UW.
- Review best practices and lessons learned from experiences in developing corporate partnerships, including the role of the UW Foundation in the development and support of corporate partnerships.

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Digital Pillar Infrastructure Working group

Charge
- Open Science by Design must be a key component.
- Make recommendations and/or models for sustainability.
- Using state-of-art data analytics – in research and in operations and management.
- Make UW competitive across all areas, especially in grants.
- Consider how AI, AR and VR could be utilized to support all activity from security, research, teaching and learning.
- Make recommendations for effective and efficient organizational structures.

Specific Areas for working group are the following.
A. **Personnel Infrastructure:** Skilled personnel as a top UW priority - attracting, retaining and farming out/in talent. Partnering for talent and joint positions with other institutions/enterprises (e.g., NCAR). Ongoing skills training for employees and faculty as another priority. Building agile career paths. Career awards. Building a mentoring culture and organizational structure. Pooled software developers and shared staff to assist across UW entities and projects. Supporting a partially remote workforce.
B. **Leverage and Further Develop University Current Digital Services/Infrastructure**
   Acknowledge that what forms part of the digital services/infrastructure are facilities in a variety of units which are not necessarily centrally operated or financed (including: Libraries, WYGISC, 3D Viz Center, Institutional Analysis, Student Services, Distant Services, Digital, Distance and Online Education, Business Operations and Processes, UW Facilities, HR, IT –

Security, Computing, Networking (including 5G and Wi-Fi 6), Center for Blockchain and Digital Innovation, Digital Scholarship Center, Center for Design Thinking, The Ellbogen Center for Teaching and Learning, Coe Student Innovation Center, Advanced Research Computing Center, 3D Viz Center, Academic Technology Services, 4D Visual Art Fabrication Studio, UW Data Science Center.

C. **Infrastructure Additions:**
Outline what infrastructure additions or reorganization are needed to best support and grow innovation, economic development, teaching and learning and research, including to better support grant acquisition. (e.g., Digital Innovation Enterprise Group, Software Carpentry Group https://software-carpentry.org/)

Conduct a '**back to basics' review** of UW information and processes, to establish what has and what needs to be digitized. Modern Dx cannot be achieved if there are antiquated processes in play, whilst institutional change is in design and implementation. This points to the need for mini local transformations to bring departments/sections up to speed and to uniform digital procedural changes.

D. **Lifecycle Replacement:** Allocate ongoing revenue sources for UW digital technology and related commitments that are expected to require long-term funding.

E. **Content Serving:** Outline how UW develops enhanced content serving platforms (e.g., Amazon-like content distribution and personalization for student information and classes), acknowledge and leverage overlap here with the Growing Partnerships group

F. **Strategic Digital Innovation Center.** Consider how to unite various digital centers such as: Center for Blockchain and Digital Innovation, Digital Scholarship Center, Center for Design Thinking, The Ellbogen Center for Teaching and Learning, Coe Student Innovation Center, Advanced Research Computing Center, 3D Viz Center, Academic Technology Services, 4D Visual Art Fabrication Studio, UW Data Science Center, for the benefit of coordinating the UW digital offering.