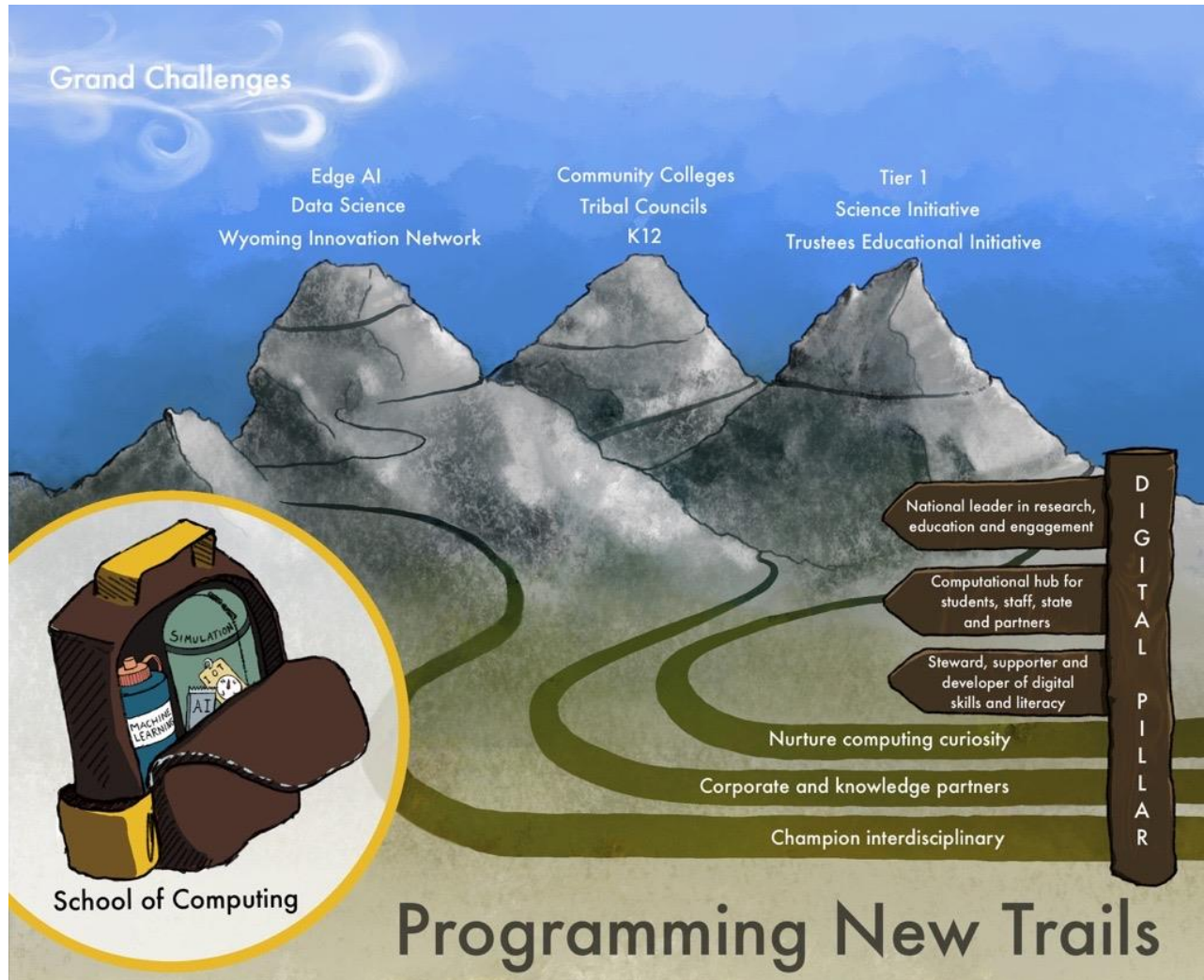


## Authorization Request for the School of Computing (SoC)

August 2021



The vision of the School of Computing (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 education, engagement and research**.

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

The SoC will champion the broader efforts aimed at making UW more digital through partnerships throughout UW and the State.

## 1. Introduction

This document is a Request for Authorization (RFA) to establish a School of Computing (SoC) at the University of Wyoming. The request includes a BA and a BS degree in Computing that will be SoC's initial curricular focus and will provide the foundation and structure for future minors to be developed and offered with other departments and programs across the campus. Additionally, a description of the SoC's leadership role in the campus-wide effort to make UW more digital will be described. Future curricular programs (e.g. the minors, as well as MA, MS and PhD degrees in Computing) will follow the approval process at the appropriate times in coming years..

This RFA references

- a) A feasibility study and market analysis on the BS in Computing Degree from the Education Advisory Board.
- b) The Digital Pillar Report prepared in Spring 2021 by a committee of 19 UW faculty, staff and students at the bequest of the UW Provost that gives a broad overview of the need, the benefits and suggest actions for UW to become more digital.
- c) The School of Computing Preliminary Plan provides a detailed description, analysis and tentative budget for all aspects (Educational, Economic and Workforce Development, Research, Partnerships, and enhanced funding opportunities).

For convenience, each of these is included as an appendix to this report.

## 2. Purpose and need for the proposed Academic Program

The following quotes from two recent studies summarize the overarching needs for the proposed “academic programs at UW:

“Computer science and information technologies have transformed all sectors of society, businesses, and government. Today, the transformation continues and much is driven by artificial intelligence, robotics, the Internet of Things, information security, and data science. A wide range of jobs in virtually all sectors demand computing skills to an unprecedented extent. And every academic discipline finds itself incorporating computing into its research and educational mission.” (NAP report)

“Computing is and will continue to be an essential component in shaping the future for humanity, The computing disciplines need to attract quality students from a broad and diverse cross-section of the public and prepare them to be capable and responsible professionals.” ACM and IEEE's “Computing Curricula 2020 report

These needs are even deeper at UW. The productivity across UW in computational education and research is far below that of peers it aspires to be like, and what UW graduates need.<sup>2</sup> Access to cutting-edge research, world-class infrastructure and workforce training in computing and data is therefore critical for Wyoming citizens, and most importantly for UW's students.

The primary purposes of the SoC curricular programs are to

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<sup>2</sup> It is important to note the scale that is needed for UW to have impact, and what is common across the nation. UW's current CS department has 8 professors (only 2 with an AI specialty) and the Advanced Research Computing Center (ARCC) has 4 current staff. Comparing the relative sizes of CS departments is only one, very limited indicator, but it does give a sense of where UW is. In 2020 UIUC, about three times UW's size, hired 23 new faculty in CS alone. Boise State, about twice UW's size, has more than 20 CS professors and plans to double in size. Notre Dame, a predominantly humanities and social sciences university, is almost exactly UW's size and has more than 4 times our CS faculty, and a unit like our ARCC with over 50 staff (almost entire funded on soft money through grants). In all cases these activities are a foundation for economic development in their region.[3]

- lead UW in the incorporation of value-added, disciplinary-specific digital computing experiences in all disciplines,
- provide more students with career pathways that utilize the power of computing and technology,
- provide new opportunities to increase the diversity among UW students utilizing computing in their disciplines and careers, and
- establish a pipeline of tech-savvy graduates for Wyoming's economy.

Additionally, the SoC will provide UW researchers new tools and cutting-edge computational expertise to better address some of the grand challenge problems of importance to Wyoming and region that they are studying, and serve as a hub for Wyoming's innovation economy.

### **3. Proposed curriculum**

The SoC is envisioned to ultimately house the following academic programs:

- Digital/Computing for All experience through the UW USP.
- Multi-pathway BA and BS programs in Computing,
- Minors in Computing,
- Certificates, possibly stackable, in Digital/Computing,
- MA/MS/PhD in Computing.

The initial ideas of these are more fully discussed in the SoC Preliminary Plan, and the Digital Pillar report. The full development of these will involve Academic Affairs, Faculty Senate, the USP committee, faculty and students, as well as an external advisory board. All will be fully studied and follow the process for approval and creation of new academic programs. Here we focus primarily on the characteristics and vision for the BA and BS in Computing programs; as they are the most critical for UW students and for Wyoming, and will be the first developed. Before that we will briefly describe the vision and plans for the other programs. All programs will be greatly informed by the recently released report "*Computing Curricula 2020 (CC2020): Paradigms for Global Computing Education*," that was developed by a 50-member task force drawn from 20 countries, CC2020 outlines international recommendations for baccalaureate degrees in computing.

#### **Digital/computing for all experiences**

The Digital Pillar report recommends that the university community consider the creation of a "digital course" requirement in the University Studies Program for all students. Their reasoning is that it is important that all UW undergraduate students learn how digital and computational methods/ tools/ approaches are becoming increasingly part of their chosen discipline of knowledge and all aspects of life. At a general level, they should be exposed to the variety of ways that digital tools can be used to accomplish tasks—many of them new tasks never before possible in areas from medicine to art and music to engineering and society, and gain introductory experience in using them. Students should gain understanding how to analyze the human, social and scientific impacts the existence and use of these tools bring. At a specific level, they should learn in greater detail and expertise how to use the digital tools available in their fields of study and understand the theory of how digital approaches and computational methods will change their fields in the future. The SoC plan proposes an Associate Dean with joint appointment between the SoC and Academic Affairs whose primary role will be tasked with leading efforts to make UW more digital through the proposed digital curriculum embedded in the USP.

#### **Minors in Computing**

Increasingly, students in many disciplines find great value-added in incorporating computing classes into their studies. Having disciplinary minors in computing gives UW Alums a competitive advantage throughout their careers, catalyzes working partnerships between UW departments and the SoC faculty, and can be used as a recruiting tool for students, graduate students and faculty. All minors will be vetted, and submitted through approval through the standard UW processes.

#### **Certificates, possibly stackable, in Digital/Computing.**

The Digital Pillar Report mentions the emerging mechanisms of certificates and stackable certificates in higher education. The SoC envisions partnering with entities like the Ellbogen Center, the Visualization Center, the Innovation Workshop, the Advanced Research Computing Center and UW Libraries to explore the feasibility of developing suites of (possibly stackable) certificate courses that enable a diverse audience of students the opportunities to gain specific 21<sup>st</sup> century skills through short-courses, self-paced courses with competency exams.

### **Graduate degree programs**

In years 2 and 3, the SoC proposes planning and developing MA and MS degrees in Computing, with a focus on development and use of cutting-edge computing tools in the context of grand challenge problems in a wide-range of disciplines. Desired characteristics of these programs will be diversity of student body, various academic pathways for entrance, collaborative projects involving different disciplines and stakeholders, ties through internships/externships with Wyoming and regional companies. A PhD in Computing will be studied and considered in years 4 and 5; other Schools of Computing support robust PhD programs off of corporate partnerships, external funding, and partnerships with national labs. Initially, the graduate curricula will be operated using existing programs in the ongoing Interdisciplinary Graduate Minor in Scientific Computing.

### **Multi-pathway BA and BS programs in Computing**

These programs will be the initial and central part of the SoC curricula, and form the backbone for multiple minors. Characteristics of these programs are:

- The BA/BS in Computing will be distinctly different than those in CS or ECE at UW, and thereby enable UW to serve more diverse set of students with interest in computing. The BA/BS in Computing will be based on the following definition of computing:  
“Computing refers to a goal-oriented activity requiring, benefitting from, or associated with the creation or use of computers.”

Thus, the BA/BS in computing will focus on the use and development of computers and related technologies to study problems of interest in a wide-range of disciplines.

First year courses will be designed with CS/ECE and other units as an on-ramp to expose students to the power of computing through diverse applications, practical and broad aspects of the development and use of application, and various career tracks in computing.

- The remainder of the curricula will be designed to offer many possible pathways to students, and to provide a platform for future minors from other disciplines to be offered.
- Following trends supported by educational research and best practices in leading computing program, the curriculum will be designed around competencies, that is, a curriculum that “focuses on an individual’s capability to perform and to apply their computing education in a practical and professional service to society. A curriculum founded on students Knowing what, Knowing how and Knowing Why. [CC2020]

### **Competency = Knowledge + Skills + Dispositions... in Context**

Competency-based curricula provide more pathways for students, the ability to quickly adjust to curricula to cover emerging topics, and provide the ability to “promote and clearly describe the practical benefits of computing programs to stakeholders: students, parents, employers, corporate partners, donors.” [CC2020]

Core competencies (e.g. problem-formulation and solving, interpersonal, management and entrepreneurial skills, ethics, collaborating, communicating, working in interdisciplinary and multicultural teams), technical competencies (e.g. DevOps, Software Development, DataWrangling, Modelling, Technical Writing), and advanced competencies in selected areas of contemporary computing (e.g. Security, Artificial Intelligence, Internet of Things, FinTech, *Contemporary Database & Interface Design Tools Human Computer Interactions*) for the programs will be identified as required elements. Each course offered by the SoC, and its partners including timely topics courses) will have an associated approved list of competencies. Students can master core competencies in different ways based upon their interests and their strengths. Over next year, a list of core competencies will be developed through consultation with an external advisory board, and a SoC Curriculum committee that includes representatives from disciplines across UW, and from Wyoming tech companies.

- The interdisciplinary nature of computing will be encouraged by a concentration in a chosen area of science, business, social sciences, etc.
- The distinction between the BA and BS degrees will be determined by the level of math-stats and the type of concentration chosen.

- Appropriate Mathematics and Statistics concepts will either be offered within existing Math-Stat courses, embedded within new SoC courses, or offered in freshly designed courses for SoC majors in mind. Different tracks within Math-Stat offerings will be available for students with different career interests.
- Experiential learning will be emphasized through class projects, internships, externships and senior design projects.

The full BS and BA programs will be developed during Phase 1 of the SoC (e.g. first two years) and informed and developed by SoC hires and an external advisory committee, and be symbiotic with the "new" CS/ECE BS programs. It is anticipated that all Computer Science related degrees at UW will share a highly common first year which will aid in recruiting, advising, costs, as most importantly give students the opportunity to discover their own areas of interest within computing.

## Proposed BA/BS program in Computing

### General Requirements (48 hours)

USP (18 hrs)

**Math-Stats (18 CR)**  
 A blend of continuous and discrete mathematics with different tracks that supports advanced computer programming, and the analysis of algorithms, and modelling.

**Disciplinary knowledge (12 credit hours, at least 6 upper division)**

### Core computing requirements (22 hours)

Introduction to Programming Computer Programming Computing Applications	Computer organization Digital systems Physical computing
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### Advanced Computing requirements (30 hours)

Students take 4-5 courses in each of two concentrations. Possible concentrations are Artificial Intelligence, Internet of Things, Computer Systems, Geographic Information Science, Modelling and Simulation, Data Analytics, Business Analytics, Human Computer Interaction, Visualization, etc.

### Concentration courses (28 hours)

Students 6-7 advanced courses, including a capstone cap-stone course which provides students the opportunity to work with students with different interests, and when appropriate with corporate partners or UW researchers, on a project from inception to completion.

The BA/BS majors will be designed to have four major components

- i. **General Requirements** (48 credits). Math, Science and University Studies.
- ii. **Computing Core** (22 credits): These courses will be jointly developed and offered with CS/ECE and SoC, with applications from various disciplines used to attract a diverse set of interests among students, and to introduce students to the wide-range of ways computing is used.
- iii. **Advanced Computing** (30 credits). Several areas of focus will be developed, such as Artificial Intelligence and Computation, Data Analytics, Computer Security, the Internet of Things, Visualization, Human Computer Interaction. Students will be required to take 4-5 courses in each of two of the foci. Most of these will be upper-level courses that are currently offered in various departments across UW.
- iv. **Concentration courses** (28 credits). Upon completion of the advance computing requirements students will be able to take advanced courses in areas of computing (such as Edge AI, Computer Systems, Modeling and Simulation, Data Analytics) as well as interdisciplinary computing concentrations that will developed with collaborating departments (e.g. archaeology, history, art, music, philosophy, environmental science, biology).

#### 4. Anticipated enrollment in BA/BS programs

Based on national reports<sup>3</sup> (xx), enrollment trends at peer institutions, and the EAB report, within the BA/BS computing majors a conservative estimate for enrollment 5 years after implementation will be and additional 150-200 undergraduate students per year in the overall computational science programs at UW.

At least 6 different minor programs in computing through partnerships with other disciplines are anticipated to be part of the SoC curricular efforts. Through these the SoC will enhance to the educational experiences to another 250-300 students per year. Finally, through its role as champion of “Digital for all” the SoC will impact every student at UW.

**Will add summary of EAB report here.**

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<sup>3</sup> “National bachelor’s degree production in computer and information science and support services at not-for-profit institutions increased significantly between 2009 and 2015 (by 74 percent), above and beyond the general rate of increase of bachelor’s degree production overall (16 percent) during this period” NAP report.

“Every two years the BLS publishes projections of employment trends for the next decade. In the most recent projections, covering the decade from 2014 to 2024, the BLS predicted that the number of people employed in computing occupations will rise from 3,916,100 to 4,404,700. The addition of nearly half a million computing jobs to the economy corresponds to a growth of 12.5 percent over the decade, compared to an overall projected growth rate of 6.5 percent. This suggests that computing occupations are growing nearly twice as fast as the labor market as a whole.” NAP report.

**5. Budget Narrative and existing or new resources required to deliver the Academic program**

A detailed five year/two-phase plan for the roll-out of the SoC and its associated programs is given in Pages 21-29 of the SoC Preliminary Plan. At the end of five years the plan targets having the following levels of personnel and programs.

- Dean
- 2 Associate Deans (one devoted to curricula, Digital for All efforts, and programs with community colleges, and one devoted to industry and research lab partnerships and workforce and economic development)
- 1 business manager, 1 office manager, 1 workforce development lead, 1 special projects lead
- 1 possible joint CWC-UW Computing position
- 21 faculty (about 25% existing faculty, remaining will be joint hires)
- 4 research scientists
- 27 graduate assistants.
- Operating budget
- Start-up funds
- Visiting faculty program
- Computing Scholars Program for undergraduates

Total projected costs at the end of year 5 are \$9.5 M per year. Year by year, item by item projected costs are provided in detail in the SoC Preliminary Plan. It should be noted

- The project costs are the anticipated all-in costs, and include programmatic elements such as a scholarship fund for undergraduates, and a visiting scholar program;
- The targeted size of the SoC is designed to support the planned MS, MA and PhD programs, as well as aggressive research programs.
- To encourage collaborations, help support departments, all SoC faculty will be joint hires with other departments.
- All SoC faculty and research scientists will have significant expectations for securing external funding through grants and corporate partnerships; by the end of 5 years SoC faculty and research scientists should bring in an additional \$7.5 M/year in external funding.

**6. Timeline for implementation**

A detailed five year/two-phase plan for the roll-out of the SoC and its associated programs is given in Pages 21-29 of the SoC Preliminary Plan. The timeline for the development and roll-out of the BS and BA computing majors is:

Spring 2022	Interim Dean and Associate Deans, and initial SoC faculty will create a Curriculum Working group that includes international experts in computing education, UW alums using computing in their careers, Wyoming tech companies, UW CS/ECE and Math-Stat faculty to design the courses for the BA/BS.
Fall 2022-Spring 2023	Offer a few trial SoC undergrad courses, fully develop other SoC courses, secure accreditation of BA/BS program, and work through UW’s CARF process for pertinent courses, establish 2+2 agreements with Wyoming Community Colleges, recruit first class of SoC undergraduates.

Fall 2023	Enroll inaugural SoC class of undergraduates
Fall 2023 and Spring 2024	Design, develop and seek approval to offer MS and PhD programs in Computing.  Evaluate, assess and make needed modifications to BA/BS programs.  Work with other UW programs on developing computing minors.
Fall 2024	Enroll inaugural SoC class of graduate students
Spring 2027	Graduate first SoC class

## 7. Plan to assess the Academic Program

Assessment of the proposed BA and BS programs will be based on student attainment of core competencies that outline in Section 3, the learning objectives described in Section 4, and informed by the SoC Educational Board and the studies such as “Computing Curricula 2020” [CC2020].

Specific assessment activities for the BA/BS programs will include:

- Pre- and post-degree exams on core and technical computing competencies
- Capstone course with assessment of final projects, including collaboration, critical thinking and communication;
- Feedback from corporate and educational partners involved in internships or capstone projects
- Surveys with Wyoming companies employing SoC graduates
- Student course evaluations
- Exit interviews with graduates

## 8. A plan for accreditation

Accreditation for the program will be established through the Higher Learning Commission (HLC), and informed by an SoC Education Advisory Panel. In order to enable to train a more, diverse student population in computing the BS/BA programs will not be ABET accredited; ABET accreditation is more restrictive on the disciplinary courses (e.g. must be science oriented) and the mathematics and statistics courses than the envision SoC programs. The SoC programs are not intended to be less rigorous, but to have more options in disciplinary content, and have mathematics and statistics courses more aligned with students’ interests and with the computing classes. Students desiring an engineering degree can pursue a BS from the ABET accredited program in CS/ECE, and if desired use their elective courses to take courses in the SoC.

Tentative learning outcomes are:

- **Outcome 1 – Communication:** Students will be able to communicate in written and oral forms in such a way as to demonstrate their ability to work with a variety of stakeholders, and to present information clearly, logically, and critically.
- **Outcome 2 – Application:** Students will be able to utilize and modify state-of-the-art computing tools and concepts to explore and analyze disciplinary problems
- **Outcome 3 – Coding:** Students will be able to code efficient programs on their own to model phenomena.
- **Outcome 4 - Depth of Knowledge:** In a selected concentrations students will demonstrate a depth of knowledge appropriate to graduate study and/or lifelong learning in that area. Students should be able to read for understanding materials in that area beyond those assigned in coursework.
- **Outcome 5 - Preparation for Career and Further Education:** Students will be prepared for a career in industry, government agencies or non-profits or for graduate study in scientific or technical fields.

Continuous improvement of the program will be fostered through annual presentations and feedback with the SoC Education Advisory Board.



## 9. Benefits of the Academic Program to the University

The proposed School of Computing will 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 **leverage 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.

## 10. The ability of the University to carry out the Academic Program

UW is positioned well to successfully carry out this academic plan, as it will build upon past investments, existing strengths at UW, and can take advantage of many pending opportunities (such as the planned large increases of funding at national agencies, American Rescue Program funding, new technologies and businesses around blockchain, and enhanced corporate partnerships around technology). The new BA/BS curricula will leverage partnerships and in particular in the co-development and delivery of courses whenever possible. The “Digital/Computing for All” program is envisioned to be a central part of a newly crafted University Studies Program.

Wyoming has consistently sought to contribute to its future by investing in the education and training of its citizens through the University of Wyoming. Recent investments, including the Tier 1 Engineering Initiative (T-1), Science Initiative (SI), and Trustee’s Education Initiative (TEI), along with capital investments in facilities provide a firm basis that focuses on the importance of Science, Technology, Engineering and Mathematics (STEM).

In the past decade, computing has become an increasingly crucial tool for research, for our graduates, and for almost all sectors of the economy. The University of Wyoming has responded by hiring faculty who use computing in their discipline, establishing programs like the Data Science Center and the Advanced Research Computing Center, and by developing a partnership with the University Cooperation for Atmospheric Research (UCAR) and its NSF-funded National Center for Atmospheric Research (NCAR) around the NCAR-Wyoming Supercomputer Center (NWSC). These have supported new modes of faculty research and increased awareness of computing across the campus.

Today, computing’s impact is found in virtually every discipline, and simulation and modeling are more important than ever, but are joined by new data science technologies like artificial intelligence (AI), machine learning and blockchain that are starting to transform every academic discipline, every industry, and every aspect of modern society. Access to world-class infrastructure and workforce training in computing and data is therefore critical for Wyoming citizens, and for UW’s students.

The SoC, along with the broader Digital Pillar plan, outline a strategic response to the computational-related needs of UW and Wyoming Community College students, Wyoming’s business and agencies. Through the SoC there are also great prospects for the University of Wyoming to emerge as a leader in rural computing and data, drive opportunities such as those anticipated via the Endless Frontiers Act and the Wyoming Innovation Partnership.

## 11. The likely value to, and impact on, students and residents of Wyoming.

The BA/BS in Computing will produce professionals fluent in the computing/digital arena. UW graduates interacting with the SoC via interdisciplinary initiatives with departments will benefit from knowledge and experience of the application of computing in their chosen domain, equipping them to be perceptive and cognizant graduates with experience in innovative applications of computing – and thus competitive in the workplace. Specific outcomes for the BA/BS degree are given in Section 4.

The SoC undergraduate programs will provide Wyoming companies and agencies with employees who identify problems (resp. opportunities for improvement, and successfully bring to bear computing and technology to re-solve the problem (help the company or agency advance through seizing the opportunity).

Citizens of Wyoming can from having SoC graduates helping agencies analyze complex problems (e.g. wildfire management) of importance to local communities and to Wyoming.

## References

[ABET20] Criterion for accrediting computing programs 2020-2021.

<https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-computing-programs-2020-2021/>

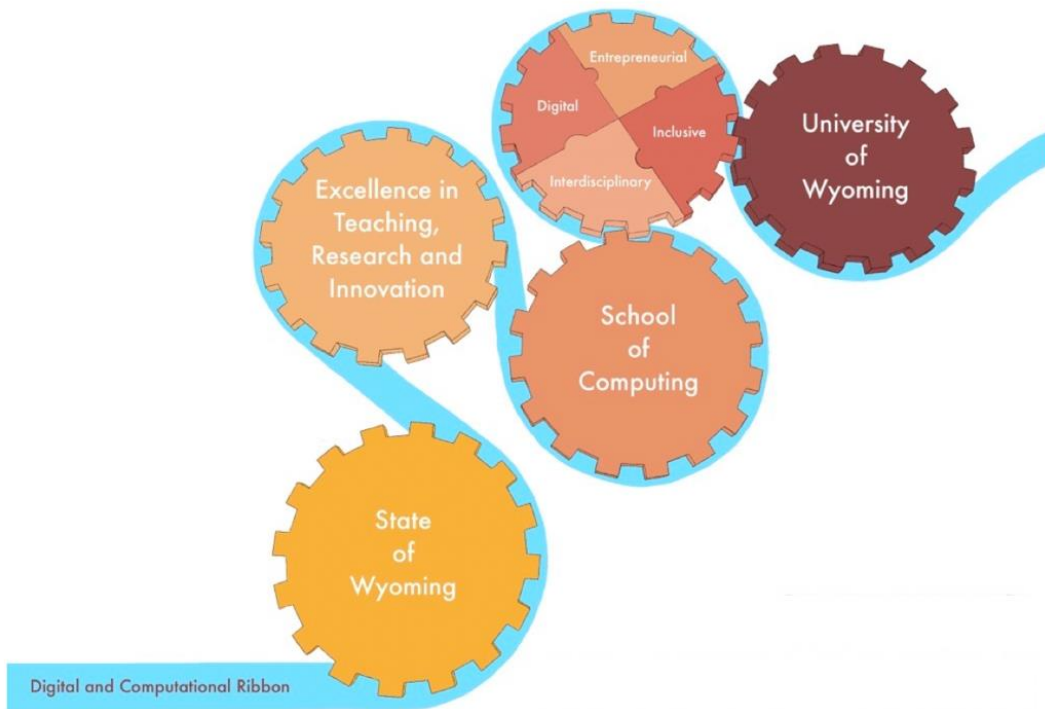
[CC2020]: *Computing Curricula 2020 (CC2020): Paradigms for Global Computing Education*, IEEE and ACM joint report, March 2021.

### Appendices:

EAB

SoC Prelim Plan

Digital Pillar Report



The School of Computing is designed to strategically mesh together existing resources and initiatives, the other pillars (more inclusive, more interdisciplinary, 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.