INSIDE THIS REPORT

The Case for Computing

Trends show that computing-skilled talent is in the highest demand, but lacks in diversity.

Our Current State

Task force research identified themes and concerns which informed our recommendations.

Our Recommendations

Tangible recommendations were developed to sieze address the case for computing and our current state.

Computing Across the Curriculum

Interdisciplinary Computing Task Force Report

April 2022

Contents

Task Force Charge

Guided by our values and goals from the strategic plan, as well as lessons learned from our previous experience in computing, the task force is charged with the following tasks:

- Create a vision and develop a program plan for a transformational initiative in interdisciplinary computing (i.e., computing across the curriculum).

- Analyze existing assets and assess workforce capacity at CU Denver for implementing the plan in the context of the Campus Strategic Plan.

- Identify high-value projects to pursue in the next three years, to include:
    - New degree programs in data science and cybersecurity
    - New modular credentials in computing writ large
    - Recommendations for complementary research programs
    - Cutting-edge computing infrastructure ideas

The Case for Computing Across the Curriculum

Computing is Intrinsic

Computing, in its many forms and ability to cut across many disciplines, has the potential to solve our most pressing societal challenges—climate change, poverty, access to healthcare and education, political inclusion, and more. It also has significant potential, due to local and nationwide demand for tech talent, to expand CU Denver's impact as a catalyst for social mobility.

Broadly speaking, we use the term computing to include concepts such as computational and design thinking, as well as knowledge in such domains as computer science, data science, data analytics, machine learning, artificial intelligence, hardware systems, and information management. Computing includes everything from basic concepts and skills in digital literacy to advanced research across the many STEAM fields.

Advances in technology and rapid growth of the information economy have made computing an intrinsic part of nearly all disciplines, including engineering, science, business, education, arts, social sciences, and the humanities. Computing is also foundational to a growing number of industries, including communication, transportation, healthcare, education, manufacturing, and financial services, all of which are using software and automation to transform their products and services. Though pervasive already, the use of computing technology in diverse fields is expected to increase as an explosion of available data and increased computing power leads to a boom in many emerging technologies, such as artificial intelligence, machine learning, internet of things (IoT), robotics, data analytics, and quantum and cloud computing.

Tech Talent Pays, But Diversity is Lacking

Trends show that computing-skilled talent is in the highest demand and among the highest paid, but the diversity of that talent does not represent broader demographics.

Demand

In our own state, the Colorado Department of Labor and Employment projects there will be more than 5,700,000 new jobs by 2032, most of which will require computing competencies for competitiveness and employability.

In a survey of non-IT and computing sectors, over two-thirds of Colorado employers said that data management and analysis is an important skill for their employees, and 84 percent agreed that digital literacy is an important skill. More than 50 percent of employers across non-computing sectors recognized an additional need for data management and analysis and digital literacy in their employees. [1] For example, healthcare practitioners now require technical

competencies in managing operating systems, developing and maintaining databases, analyzing spreadsheets, and visualizing data—skills for which they were not initially trained.

Looking at two studies more specific to computing and technology fields, employers cited key areas of growth in 2022 to include: artificial intelligence; machine learning; data science and analytics; software development; and technical writing. [2, 3]

84% of non-IT and computing sector empoyers said digital literacy is an important skill.

Pay

Responding to that demand, employers are willing to pay substantially more for job seekers with computing skills. Median wages for computer and information technology occupations ($91,250) are more than twice the median wages for other occupations ($41,950). As examples, computer information and research scientists with a master's degree have a median income of $126,000 per year, while computer network architects and information security analysts command more than $100,000 annually with just a bachelor's degree. [4]

Diversity

Unfortunately, the diversity of talent in these high-paying fields, both in gender and race. If we look just to the Denver metro region, tech talent is disproportionately white compared to population statistics. According to U.S. Census Bureau data compiled by the Metro Denver Economic Development Corporation, nearly 80 percent of all tech talent in Denver is white, followed by Asian (9.3%), Hispanic (7.1%) and Black (2.4%). Population statistics for the Denver metropolitan area show that 65% of residents are white, 23% are Hispanic, 5% are Asian, and 5% are Black. [5] According to the Pew Research Center, women comprise only one-fourth of jobs in computer science. [6]

While there are broad efforts in place to improve these disparities, there is need for additional focus and investment to diversify talent pipelines. This is where we see CU Denver's advantage and opportunity.

CU Denver's Advantage and Opportunity

Combining computing's influence as an economic driver, the demand for diverse tech talent, and CU Denver's ambitions of becoming the nation's first equity-serving institution and a university for life, we believe the university is primed to diversify tech talent, grow academically, expand social mobility, and increase our impact in Denver and beyond.

In the following pages, we lay out findings and recommendations that position CU Denver as a positive force for change in this space.

1. Develop a "CU Denver Tech and Computing Hub" and invest in supporting strategies to ensure we are at the cutting-edge of computing education.
2. Develop sets of computational competencies to equip all CU Denver students with these in-demand skills.
3. Develop and deliver deeper academic and experiential programming to complement our broader computational competencies.
4. Expand comprehensive student support needed to teach and learn in this space.
5. Invest in faculty and staff to deliver this education and pursue these initiatives.
6. Invest in the infrastructure necessary to realize these ambitions.

Our Current State

Before developing recommendations about where we should go, the ICTF assessed our current state with input from students, faculty, staff, and administrators across all schools and colleges.

Our Approach

To add structure to our work we built our inquiry and ideation around the Design Innovation (DI) process with a specific focus around discovery of needs and creation of actionable recommendations. Each member of the team surveyed their networks within the university, including students, to address seven key questions:

1. How do you use computing in your research field or teaching?
2. What was your best and worst experience with technology or computing tools in your discipline?
3. How has computing changed your field/industry and what are trends we should know?
4. Where has your school/college/unit already integrated computing?
5. Where do you see opportunities for greater collaboration or integration of technology or computing within your discipline?
6. What barriers, challenges or gaps currently exist and what do we need to do to address them?
7. What approaches or resources might we need?

Through a combination of 1:1 interviews and a Qualtrics survey, we gathered insights from more than 230 students, faculty, and staff. In addition, the ICTF was made up of 13 individuals who represented perspectives from their own schools, colleges, and units. Data gathered throughout this process can be found in the appendix of this document: themes can be found in [7], and the complete results of the Qualtrics survey in [8].

Our Findings

Our research confirmed the following themes and revealed concerns which inform our recommendations:

Courses/Training

Computing opportunities are inconsistent across the campus.
The task force assessed existing computing learning opportunities in each of the schools and colleges, finding that the College of Engineering, Design and Computing (CEDC) had the broadest set of introductory offerings. CEDC computing offerings include six introductory programming/coding courses, as well as more than 40 upper-level undergraduate computing courses. Business and CLAS, each have two introductory computing courses, as well as more-focused courses in specific disciplines. In CLAS, there are several introductory and many (over 80) upper-level courses containing or focusing on computing, data analysis, or data literacy. The task force found other colleges did not have introductory courses or focused technical courses, but still had course work with adjunct computing attached to them (e.g., interactive design, current gaming courses, and CAM offerings). Details of the existing coursework can be found in Appendix C.

Before a student's computational education can begin, the student must acquire basic competencies in typing, data literacy, and digital literacy.
In assessing educational opportunities, a number of specific, foundational needs emerged. One of the more surprising findings was that many incoming students do not have sufficient typing skills, which disadvantages the student before they can even begin to gain other computational competencies. Basic data literacy, whereas students do not know the most fundamental concepts in managing data or working with common tools for manipulating data, also presented itself as a foundational need. A third finding emerged around the use of universal software suites commonly used in the workforce, such as Microsoft Office.

There is a need for on-ramping courses offered as micro-credentials.
For students lacking basic digital skills, the task force task force found a need for on-ramp courses that would equip students with the digital literacy skills necessary to jump into higher level computational courses. These could include basic/intermediate analysis tools such as Excel or Jupyter Notebooks or software development tools such as GitHub.

There is a need for computing related apprenticeships and internships on campus.
Federal and state departments of labor have provided incentives to create internships and apprenticeships. Employers interviewed by the task force expressed strong interest in having students engage through such programs. The task force's findings point to an opportunity to better utilize these kinds of professional development opportunities to enhance computing and technological skills. Currently, apprenticeships in coding, data science, and cybersecurity are under development, and additional areas might be worth pursuing.

A number of new computing-focused degrees are launching or will soon launch, and there is opportunity and need for more.
The task force found that new degree opportunities are emerging within the core of computing, in addition to interdisciplinary courses across campus. The B.A. in Computer Science has grown to 200 students in the two years since its launch. Despite this apparent early success, the task force found there remains great untapped potential for the degree and full realization of the CS+X model. (The BA degree enables students to study a discipline of their choosing combined with a more accessible understanding of computer science, often earning two degrees with 120-130 credits.) The recently approved B.S. in Cybersecurity continues this interdisciplinary approach to computing by combining technical cyber skills with business and risk assessment. A third degree, the B.S. in Data Science, is currently being developed across three colleges as a first-of-its-kind degree. Other degrees are being considered, including a gaming design degree out of CAM with a strong technical basis and ties likely to CLAS and CEDC.

There is a need for computing and data ethics to be integrated into existing and new courses.
A critical, emerging area that crosses numerous boundaries is that of data and computing ethics. The task force found it would be important to develop meaningful content in this area for a variety of existing courses, as in addition to a number of new ethics-specifics courses.

Infrastructure

Broadband access on and off campus is currently inadequate.
As highlighted during the COVID-19 pandemic, internet connectivity is critical. Unfortunately, the task force found that students need assistance acquiring Wi-Fi access at home and the campus needs improved broadband infrastructure. In the most extreme cases, students are seeking creative and alarming ways to access broadband, such as using garage parking spaces to connect to CU Denver Wi-Fi. On campus, the task force found inadequate broadband access with much less than half of the campus providing sufficient Wi-Fi to support the applications necessary for learning. There are numerous buildings where Wi-Fi access is uneven, and in some places completely unavailable. This inadequacy goes beyond Wi-Fi access points and includes a need for additional fiber infrastructure upgrades to provide sufficient internet connectivity.

Students need collaboration spaces with access to state-of-the-art technological support.
The task force found students are seeking places on campus to collaborate, such as modern computer labs/tech spaces that can facilitate multidisciplinary efforts. Notably, another campus committee, Strategic Enrollment Management, identified a collaborative multi-disciplinary workspace with adequate tech resources as a potential marketing tool because of its appeal to students.

Students have inadequate access to mobile computing devices, and they need help navigating federal opportunities for resources.
Based on surveys from two years ago, at the beginning of the COVID-19 pandemic, the task force became aware that many students do not have adequate access to computing devices. Without laptops or tablets, many students rely on smart phones as their primary computing devices. Smart phones lack the features and software support to be adequate, but students' heavy reliance on them highlights the need for mobility and accessibility. Mobility is a critical component in modern higher education, and therefore a desktop computer is insufficient. In its surveys, the task force found that students had either inadequate (older generation) computing devices or none whatsoever. Students were also not aware of Federal programs to assist consumers in acquiring broadband devices and broadband access.

Infrastructure inadequacies include authentication and access to resources.
Infrastructure is not limited to devices and internet access, but also includes typically behind-the-scenes requirements. For example, the task force found that authentication is a sticking point for students and faculty. Students pointed out that authentication poses challenges to accessing resources they need, both while on campus and at home. Problems with authentication may be valid or could be a function of users not knowing the proper procedures, but either way, a simple, consistent protocol seems to be lacking.

Tools

Students need access to better technical support for their computing needs.
Both students and faculty pointed out the need for a set of common, accessible tools, as well as 24/7 IT support. With the university's ambitions of serving students from the ages 17 to 117 and our high proportion of first-generation students, the task force found it is necessary to have accessible support at non-traditional hours as many students work and have other obligations that require them to focus on school during non-business hours. Students noted that they would prefer courses to utilize open-source software and resources, because software and resources that require licensing and money to purchase are an impairment to their educational experience.

Not all faculty have adequate technology or training to teach using modern LMS tools.
A substantial number of faculty interviewed indicated that there are widespread struggles navigating the additional IT requirements associated with teaching online or hybrid courses. Given that online and non-synchronous learning content is becoming increasingly popular, the task force found the need for all faculty to have tools and competencies in online teaching.

Software packages are inadequately managed across campus.
IT staff pointed out the need for mechanisms to better manage software tools maintained across campus. This includes making sure that software is upgraded, licenses are maintained, and that software is accessible to students, staff, and faculty. The task force found that challenges occur when teams are managing hundreds of different packages within a single college, and this difficulty spotlights opportunities to manage software in a more centralized, efficient, and cost-effective manner.

Diversity, Equity, and Inclusion

There are gaps in terms of internet and device access, highlighting concerns about equity in computing.
In our surveys, the task force found unequal access to internet and devices, cutting across racial and social lines and negatively impacting some students' abilities to keep pace with program requirements. As conveyed earlier, many of our students have inadequate computing devices and/or access to the internet. These discrepancies were more profound among our students of color.

The disabled community faces unique and compounding challenges in computing education.
The task force found the disabled community is faced with challenges in terms of using computing tools on campus. Software can be a great aide to accommodate students with physical or learning disabilities, but it also can be a hindrance to these students if it lacks accessible features. With hundreds of software platforms being used across the colleges, there is inconsistency when it comes to their accessibility. Students expressed a need for staff and faculty to select software with accessibility accommodations in mind. Also, with respect to physical spaces dedicated to computing and technology, students with physical handicaps may experience challenges.

There are several factors that deter diverse students from pursuing a computational education.
For many students, seeing someone who is like them succeeding in the field of computing can be a catalyst for their own growth and learning. The task force found a lack of representation of marginalized groups in these fields makes it hard for underrepresented students to gain access to and excel in computing-based coursework. Additionally, more inclusive practices, such as employing software from diverse creators and using multilingual capabilities, would make the field of computing more accessible. Remarkably, this finding directly relates to some of the issues with racial and gender homogeneity in tech industries.

Relationships

Limited relationships with external partners lead to an insufficient understanding of incoming student capabilities and future employers' workforce needs.
Discussions with faculty and other key stakeholders demonstrated a gap in our relationships to K-12 school districts, community colleges, and potential employers. The task force found the university has neither a coordinated approach, nor the resources to gather market data that would illuminate the needs of employers. Additionally, there is great opportunity to expand partnerships with K-12 school districts or community colleges to inform the needs of students coming into CU Denver. The task force found expanding information in these areas would ensure we successfully equip students with the skills necessary to compete in the workforce.

Financial

Additional financial resources as well as transparency for technology investments and maintenance are needed.
In its surveys, the task force heard a clear, consistent issue around the inability to pay for services and infrastructure. Students pointed to the inability to purchase laptops and home internet access, as expressed above. Staff and faculty communicated that schools and colleges struggle to keep up with the financial cost of renewing hardware and software required for their programs, as well as the maintenance needed for students, staff, and faculty.

Financial constraints and inefficiencies are worsened by redundancies and gaps in the IT structure.
The task force's surveys found several OIT-related financial constraints, including the pay-per-service model. Some pointed out that a few OIT services should be provided as a campus-level service, rather than pay-per-service. Many respondents also pointed out the redundancies and gaps between IT services within a college and those provided by OIT. Lastly, it is unclear how the campus should pursue a path towards modernization, including moving more services to the cloud and adopting novel software solutions that might be free or at a much-reduced cost, compared to current commercial packages.

Administrative structures, including the financial model, must incentivize and reward interdisciplinary collaboration for teaching and research.
The task force received feedback that current budget models create competition among schools and colleges, reducing incentives to collaborate on interdisciplinary programming. Faculty pointed out that the budget model should reward, not disincentivize, interdisciplinary teaching and research. Furthermore, many faculty are not even aware of how to interpret the financial models when approaching leadership for teaching and research collaboration. Beyond the financial model, the task force found removing administrative barriers to cross-college offerings (degree and otherwise) would foster innovation in our curriculum and pedagogy.

Efforts to enhance computing will take money, time, and the recruitment and retention of expertise.
An important corollary to the financial needs is the realization that implementing any wide-spread computing upgrade will take time and talent, in addition to funding.

Expertise

Computing knowledge is unevenly distributed across campus and there is a need for "training the trainers."
As the task force assessed computing education across the university, it found an unevenness in the distribution of expertise to engage in propagating computing across the curriculum. Numerous colleges stated the need to "train the trainer," as well as provide faculty and staff support for enhancing computing skills. This statement is not to imply that each college does not have expertise, but expertise is often narrow in scope and found among only a few faculty members, thereby making it inadequate to serve as a basis for bootstrapping broader teaching efforts.

There is a need for more internal relationship building through inter- and intra- college collaboration.
The task force also found the need to better connect faculty who have expertise in computing fields. Faculty members mentioned in interviews that co-teaching may be an effective avenue for building interdisciplinary conversations and sharing information. Additionally, there is an opportunity to better understand community practices for sharing and teaching—even simple measures like inter- and intra- college seminars on computing. These offerings have been integrated into our collaborations with the Anschutz campus, providing a successful model for institutionalization at CU Denver.

There is an opportunity to enhance CU Denver's research output by integrating computing into more collaborative research efforts.
Findings point to extensive computing related research across CU Denver, including pockets of collaborative, integrative computing research. The one unifying trend in this collaborative/integrative research is the application of data science and/or data analytics. This integrative, data science-focused research aligns with funding trends at the federal and industry levels. Investing and continually upskilling faculty with modern computing tools will help keep our research at the cutting edge.

Our Recommendations

With these findings in mind and to seize the opportunity laid out above, the task force identified a set of tangible recommendations.

Recommendations

1 University-level governance

- Virtual School of Computing and Technology
- Engage new partnerships
- Cutting-edge coursework
- Develop education strategy
- Reduce interdisciplinary barriers

2 Computational competencies for in-demand computing skills

- Establish digital literacy standards
- Assess students' digital competencies
- Free courses for students to meet digital literacy standards

3 Innovative academic and experiential programming

- Develop programming within five initial tracks
  - CS+X
  - Cybersecurity
  - Health-Related Programming
  - Data Science
  - Game Design
- Expand on cross- discipline modules, micro-credentials, and on-ramp courses
- Create flexible entry points and attendance

4 Comprehensive support needed to learn

- 24/7 support for students.
- Technology Resource Center (TRC)
- Digital Literacy Navigators
- Expand hardware and software availability

5 Faculty and staff investment

- Recruit 100+ diverse faculty and staff
- Expand integrative computing research
- Better support systems for pedagogy and practices on the cutting edge.
- Staff support and strategies

6 Infrastructure necessary to realize these ambitions

- Optimize current technology
- Invest in additional technology
- Coordinated and efficient technology management

Recommendation 1: Develop a "CU Denver Tech and Computing Hub" and invest in supporting strategies to ensure we are at the cutting-edge of computing education.

The task force found that an interdisciplinary approach to computing would face challenges without a coordinated strategy that spans all schools and colleges. This strategy should be housed within a "CU Denver Tech and Computing Hub" that integrates our capabilities and provides ongoing direction to these recommendations. Additionally, the hub will allow us to flexibly organize talent and resources across schools and colleges and rapidly respond to market demands with cutting-edge education, research, and innovation.

- Build a "CU Denver Tech and Computing Hub" to provide an ongoing, comprehensive strategic direction to computing activity at CU Denver.
    - Recruit a world-class leader of the hub.
    - Create an advisory board of students, alumni, industry professionals, faculty, and staff to drive conversations regarding emerging technologies and needs within industry.

- House the hub in a signature, innovative physical space in the new CEDC building.

- Amplify engagement with the public and private sector through new partnerships.

- Develop and implement an internal education strategy around computing education to increase understanding and success of the hub.

- Develop a robust external marketing and communications plan to raise visibility spotlight our innovation in this space.

- Reduce bureaucratic barriers to creating interdisciplinary offerings, and create standards for offerings – degrees, courses, micro-credentials, etc.

- Revise the budget model to encourage collaboration and support the creation of interdisciplinary offerings.

Recommendation 2: Develop sets of computational competencies to equip all CU Denver students with in-demand computing skills.

Leveraging the "CU Denver Tech and Computing Hub", the task force recommends that CU Denver create and disseminate a set of computational competencies suitable for all students entering into and graduating CU Denver. General skills/content would need to be determined and created by a university wide faculty committee while specific, more advanced skills/content would be left to each school and college.

With a stronger and common foundation of digital understanding and proficiency, students will be able to build higher-level skills and be more successful at CU Denver. This success may produce collateral benefits that increase retention: perception of CU Denver being a good institutional fit, higher satisfaction with the curriculum, increased persistence, and stronger commitment to degree completion.

- Establish a campus wide digital literacy standard to set students up for greater success while at CU Denver and in their careers.
- Develop a campuswide approach to assessing and recognizing (e.g., badging) a student's digital competencies, including typing, application terminology, digital ethics, etc.
- Develop school and college-specific digital competencies that leverage the campus-wide approach and framework.
- Develop free-of-charge, flexible on-ramp courses as well as additional support for students who do not meet digital literacy standards.
- Embed these contemporary digital competencies into the core curriculum.

Recommendation 3: Develop and deliver innovative academic programming to expand upon our broader computational competencies.

CU Denver has already successfully begun to instill a mindset of computing across many disciplines. Building from this foundation, and responding to the market data presented earlier, the task force recommends we expand our suite of academic programming through the "CU Denver Tech and Computing Hub"

There are multiple disciplines that the task force anticipates could expand into this space, and various channels that would increase accessibility for learners at all stages of life. The task force recommends dynamic, layered academic programs, initially organized around six key themes. Each theme would feature four layers of academic programming specifically tailored to meet our

university for life ambitions: (1) credit-bearing degree programs; (2) credit-bearing modules that could be added to a CU Denver student's coursework; (3) non-credit micro-credentials to upskill and bolster a student's ICT knowledge; and (4) easily-tailored on-ramp courses that could be delivered for learners of various kinds—K-12 students, K-12 educators, industry partners.

The task force imagines these themes to be evergreen, not because each theme will live in perpetuity, but because the hub would consistently evaluate market data and input from stakeholders to refine its offerings and develop new themes that meet market demands.

- Develop, expand, and market programming within six initial themes in the "CU Denver Tech and Computing Hub":
    - CS+X, connecting computer science with disciplines across the university
    - Data Science, cutting across all schools and colleges
    - Cybersecurity, connecting CEDC and the Business School
    - Game Design, centering on the College of Arts and Media
    - K-12 Teacher Training, centering on the School of Education and Human Development
    - Health-related programming, connecting disciplines such as medicine, health analytics, data science, artificial intelligence, and CU Anschutz

- Following the same structure used for the six themes, expand:
    - credit-bearing modules for degree seeking students across disciplines.
        - Develop a four-course series of Swift Coding focused on social impact.
        - Develop a four-course series on data science
        - Create interdisciplinary capstone learning opportunities that apply concepts in real-world work environments.
    - non-credit micro-credentials.
        - Data Visualization
        - Intro to Data Science
        - Intro to Design
        - Intro to Cloud
        - Data and Digital Ethics
        - Digital Citizenry
        - Mobile App Development: Android Developer Certification
        - iOS/Swift Certification
        - Adobe
        - Microsoft Suite
        - GitHub
        - Jupyter Notebooks
        - Ethics + Technology in Business
    - on-ramp courses.
        - P-12 students (e.g., CU Succeed)
        - P-12 educators
        - specific industries and companies seeking to upskill their employees.

- Create flexible entry points and attendance structures.
    - Offer courses at multiple starts per academic year
    - Expand hybrid options
    - Maximize credit for prior experience
    - Enable students to opt-out of modules in which they are already competent to focus students' learning and resources where it is most needed

Recommendation 4: Build the comprehensive ecosystem needed to learn.

For students to be successful in computing and technology-related courses, we need to provide more comprehensive and accessible support, as well as experiential learning opportunities that complement their in-class learning. These efforts are particularly important as we work toward becoming the nation's first equity-serving institution and a university for life. We must consider what support looks like for students outside of traditional business hours, who provides that support, and how students access support, whether in person or virtual. We also must recognize that our students who most need additional support are the people with the least access to technology, exacerbating equity issues in technology and computing.

- Ensure 24/7 support for students.
    - Establish a Technology Resource Center.
    - Staff the Technology Resource Center with student digital literacy navigators who are equipped to help other students resolve areas of specific need.
    - Expand hardware and software available to students.

- Aspire to provide every CU Denver student with a laptop upon their matriculation and secure extramural funding to support it.
    - Provide students with the hardware required to complete their classes and have in place a system that allows students to opt-out if they have sufficient resources.
    - Create a highly accessible, modern, virtual coding environment where faculty can develop computing curriculum and students can learn and write code.
    - Expand campus wide efforts to provide students with affordable broadband services through university partnerships with local internet providers.
    - Create a software dashboard that allows students and faculty to learn about available software and applications.
    - Establish an outreach team to help qualified students obtain federal assistance.
    - Create landing zones where students can work with mobile computing devices and have access to secondary screens, broadband connectivity, and open workspace.

- Expand experiential learning opportunities related to computing and technology.
    - Expand industry partnerships that connect students into real world opportunities.
    - Create project-based capstone learning opportunities that bring together students across disciplines to apply concepts.
    - Expand co-curricular and extracurricular events and competitions, clubs, support organizations, building off successes such as Data 2 Policy and the Math Modeling Competition organized through the mathematics and statistics department.
    - Create a campus-wide annual computing competition focused on social issues important to CU Denver and secure extramural funding to support it.

Recommendation 5: Invest in faculty, staff, and graduate students to realize our computing ambitions.

These bold ambitions—a "CU Denver Tech and Computing Hub", expanded academic programming, and reimagined student support, among others—cannot be achieved without additional human resources and greater support for our people. The task force recommends expanding partnerships with the Center for Excellence in Teaching and Learning, increasing staff training, and elevating the recognition of our people, costs that the task force sees as investments rather than expenses. Additionally, CU Denver should make bold moves to hire diverse faculty with computing expertise across multiple disciplines in the next five years. Leaning into our equity-serving institution ambitions, these hires should be intentionally focused on people of color and women.

- Develop a strategic hiring plan to recruit 100+ diverse faculty and staff over the next five years in disciplines that touch computing.
    - Utilize strategic campus investments to support startup packages and incentivize schools and colleges to hire in alignment with computing ambitions.
    - Leverage cluster hires to excite and attract diverse top national talent.
    - Pursue collaborative hires with industry and labs to subsidize cost (i.e., negotiate 10 joint hires with a national lab).
    - Invest in world class leadership to advance and boost, program development, recruitment of talent, and fundraising.
    - Partner with CU Anschutz to build leadership in computing related to health and medicine.

- Invest in integrative computing research across the university.
    - Ensure we recruit faculty with nationally and internationally recognized research programs related to our computing ambitions.
    - Leverage the “CU Denver Tech and Computing Hub” to organize and catalyze integrative computing research across the Colleges and Schools.
    - Seed new efforts within the research grand challenges process.
    - Build strategic bridges with potential partners outside CU Denver, CU Anschutz, and others.
    - Expand entrepreneurial efforts and infrastructure to bring CU Denver research to market.
    - Hire additional staff to identify funding opportunities and expedite grant writing.
    - Expand support to graduate students critical to the growth of our research ambitions in this space.

- Develop faculty support systems and strategies to ensure our pedagogy and practices are at the cutting edge.
    - Ensure faculty can use necessary programs for their teaching and research and that cutting edge applications and methods are updated regularly.
    - Expand and incentivize trainings through targeted Skillsoft classes as part of the faculty’s entry to and continued employment in the university system.
    - Pursue partnerships with leading tech companies to provide introductory access to programming courses for all faculty, staff, and students.
    - Develop communities of practice through faculty development offices and/or lunch-and-learn activities.
    - Create technology kits for faculty teaching in hybrid classrooms.

- Expand staff support and strategies to enable these ambitions.
    - Expand adviser knowledge of computing education and offerings.
    - Bolster marketing and communications staff, budget, and support to ensure we can meet our goals for enrollment.
    - Hire industry liaisons with assist with expanding partnerships.
    - Provide support for these ambitions through project management and administrative help.

Recommendation 6: Invest in the infrastructure necessary to realize these ambitions.

Currently, technology across the campus is managed independently by schools, colleges, and units, which has led to inefficiencies and gaps in service to our students, faculty, and staff. Infrastructure, hardware, software, and physical space cannot be overlooked if we are to seize the opportunities before us and realize these ambitions. Making these investments will ensure CU Denver is capable of successfully delivering academic content and graduating students prepared to achieve in a computing-driven world.

- Create highly visible kiosks and spaces within the new CEDC building to amplify participation in the “CU Denver Tech and Computing Hub”.
    - Provide meeting and co-working spaces for students, faculty, staff, and partners to facilitate multi-disciplinary collaboration.

- Assess our current technology across campus.
    - Conduct an audit of hardware currently being used across campus (building by building).
    - Develop and implement a campus wide approach for technology management and a minimum technology standard for all CU Denver spaces, informed by the audit.
    - Ensure all computer labs are updated with the campus-wide solutions generated by the hardware audits.
    - Ensure ease use of technology in classrooms across campus.

- Invest in additional technology informed by the campuswide minimum technology standard.
    - Offer and maintain better Wi-Fi and Fiber trunks.
    - Create foundations for higher-level computing and remote access using container environments, virtual desktops, and the University Virtual Private Network (VPN).

- Ensure technology management is coordinated and efficient moving forward.
    - Create a Cloud strategy for the campus.
    - Form a team of specialists with the primary focus of procuring, managing, and maintaining technology across campus.
    - Clarify and confirm roles and responsibilities for managing technology across campus.
    - Create a system for students, staff and faculty to provide feedback.

When We Are Successful

Success in these ambitions will have tremendous impact on CU Denver. We estimate these investments could attract thousands of new learners annually and generate significant additional revenue.

More personally, however, we believe our success would be better conveyed by the learners we serve and the mobility they attain for themselves through an innovative approach to infusing computing across the curriculum. This could include the middle-aged parent who upskills into a higher earning role for her children; the high school student who makes higher education more affordable by earning college credit through expanded dual enrollment; and the first-generation student who proudly takes graduation photos with his parents before entering a high-paying tech job.

We believe CU Denver is primed to take on these recommendations and equip more of our students with computational competencies to innovate across industries, strengthen economies, and improve society.

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