Computing by Design:

A Framework for Providing K-12 Computer Science Education

INNOVATION CENTER of St. Vrain Valley Schools

ST. VRAIN VALLEY SCHOOLS
academic excellence by design

COMPUTING BY DESIGN

SEEING COMPUTER SCIENCE IN OUR SCHOOLS

INTEGRATION

DISSOLVING BOUNDARIES BETWEEN CONTENT AREAS

- Instruction: Engaging, relevant and age-appropriate CS curriculum; integration of CS into core content; effective and on-going professional development; parent and community engagement.
- Planning: Computer Science Teachers Association standards; Tier-1 instructional best practices; SVVSD Teaching-Learning cycle; K-12 vertical alignment; data-driven instruction, performance assessment, formative assessment.
- Technology: robust technology infrastructure; universal access.

PROBLEM SOLVING

SEEING CHALLENGES AS OPPORTUNITIES

- Design Thinking: Incorporating human-centered design thinking into CS instruction.
- Inquiry: Intentional design of CS curriculum incorporating inquiry and problem-based learning.
- Bias Towards Action: CS as tool for improving our world and solving key 21st century problems.

21ST CENTURY SKILLS

GOING BEYOND THE MEASURABLE

- Creativity, Critical Thinking, Collaboration, Communication, Character.
- Traits: Building resilience; learning from failure; giving and receiving valuable feedback; backing up claims with evidence; presenting and communicating findings; and applying knowledge to unique problems.
- Life-long Learning: Students are empowered to be independent learners; understanding that technology is constantly changing.

PERSONALIZED LEARNING

HAVING A SAY IN WHAT AND HOW WE LEARN

- Student Agency: Academic, personal, professional, entrepreneurial, and civic competencies.
- Student Voice: Connecting CS with personal interests and needs; empowering students with choice; following curiousity; student ownership; teacher as facilitator.
- College & Career Readiness: CS careers for every interest; CS skills in every career; College in Colorado; Individual Career and Academic Plan (ICAP).

CONNECTION

BUILDING RELATIONSHIPS WITH PEOPLE, PLACES, AND PROFESSIONS

- Academic: Connecting CS with personal interests; connecting learning with real world applications.
- College & Career Awareness: Internships, mentors, P-TECH, STEM Career Connections.
- Community: Mentors for teachers and students; outreach and partnerships, family connections and involvement; students teaching students.

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science | technology | engineering | math

Vision, Mission and Values

Vision: Our vision is to create a roadmap for implementing K-12 computer science education. We want to inspire educators and students to view computer science as a means for being creative innovators and problem-solvers, and to prepare them for success in a future shaped by technology. Through this, we hope to demonstrate public education's value to the community and inspire confidence in all of our stakeholders. We hope our framework will:

- provide a roadmap to educators for how to implement computer education
- inspire educators and students to be innovators and problem-solvers
- prepare students for a future based on computer science
- heighten the value public education has to the community
- support and sustain an environment that is conducive to computer science education

Mission: In order to achieve our vision, we will:

- educate and train educators (teachers, administrators, parents, etc) on an on-going basis
- provide affordable, effective, current and age-appropriate resources to all schools
- continually assess the effectiveness of curriculum and tools used in this implementation
- develop, implement and refine high-quality, standards-based curriculum in collaboration with practicing educators and professionals in the field
- stay current in a continuously changing discipline

Values: Our vision and mission are based on the following key values. We believe these values are shared by educators, students and community stakeholders alike.

1. **Computer science is a 4th literacy for the 21st century:**
   Computer science informs and shapes nearly every aspect of our 21st century world. In order to successfully negotiate this dynamic and complex world, students and teachers need a foundational understanding of the technology and processes that shape it. They should be confident and optimistic about the role that computer science plays and

embrace the opportunities it presents rather than feeling threatened or overwhelmed by them.

Approaching computer science as a 4th literacy involves teaching computer science for computer science's sake, but also utilizing it to enhance other areas. Computer science literacy is adaptable and transferable. It informs and supports all areas of K-12 education, and thus, with intentional design, can be easily integrated into existing curriculum. In particular, it strongly supports math and science instruction as well as integrated learning.

Computer science is much more than programming, coding or using technology. At its core is computational thinking which works at solving a problem through a disciplined process of understanding the problem and user needs/interests, decomposing the problem, collaboratively developing a plan to solve problem, going through the iterative cycle of developing, debugging and consulting with the client, implementing a solution, then maintaining and supporting the end product. Ultimately, computer science is about developing the skills to be an effective problem solver.

Computer science is a dynamic, ever evolving field. While the process of computational thinking remains relatively constant, things like devices, operating systems and programming tools such as SDKs change and are replaced. Success in computer science requires adaptability and the willingness to be a life-long learner as well as 21st century skills such as collaboration, communication, and creativity.

2. **Computer science is for everyone and can be learned by everyone:**
   Computer science connects to all types of people and interests. With intentional and thoughtful implementation, a computer science program can meet the needs of all students, including all traditionally underrepresented groups. For example, considering the large variety of free or low-cost resources, beginning a computer science program requires little monetary investment. Moreover, these kinds of resources are available to all ages, often in multiple languages and in different avenues. Unplugged activities, for instance, can be completed without using a computer.

Making computer science inclusive begins with creating an environment that is open and safe so that everyone feels comfortable sharing ideas, providing constructive criticism, and actively listening to multiple points of view. This type of environment creates trust and encourages everyone to challenge their own ideas, values and mindsets. This diversity ultimately promotes more effective and creative problem solving.

3. **Computer Science Empowers Students and Teachers:**
   Students and teachers literate in computer science disciplines are empowered to be creative innovators and problem-solvers with technology rather than passive consumers of it. They recognize and understand computer science's inherent value as well as can apply its technologies, thinking and techniques to existing and new contexts. They are able to use computer science for personal interests as well as a tool for achieving professional and other goals. In other words, computer science-literate people use technological tools purposefully and proactively, not reactively.

   In general, computer science cultivates the necessary dispositions for overcoming 21st challenges and seizing 21st century opportunities. These dispositions include, among others, curiosity, creativity, initiative, logical thinking, the ability to identify and solve important problems, perseverance, learning from failure, and the ability to collaborate and communicate effectively.

4. **Computer Science is Essential for Post-secondary Readiness:**
   - CS is a powerful tool for innovating solutions to 21st century problems
   - US Department of Labor anticipates main source of job growth/opportunities will be in areas of or relating to computer science
   - A fundamental understanding of computing and computing practices will be necessary for jobs not directly related to CS
   - With computing's ubiquity, students need to have a strong understanding of its ethical dimensions and challenges

Guiding Questions

1. Is computer science a 4th literacy for the 21st century?
2. What disciplines comprise computer science?
3. What are essential computer science knowledge, skills and dispositions?
4. How can we ensure all SVVSD students have regular access to high-quality computer science education?
5. How can computer science curriculum be aligned K-12? What will be distinctive at each level, what will be the same?
6. How does computer science relate to other content areas and district learning objectives?
7. Who provides leadership in computer science education?
8. What are valid and meaningful ways of assessing computer science literacy?
9. How can all teachers become computer science literate?
10. What are professional development requirements for fully implementing computer science education and providing support to sustain it?
11. What are infrastructure requirements for fully implementing high-quality K-12 computer science education?
12. What are staffing requirements for fully implementing high-quality K-12 computer science education?
13. How do we addresses the continuous changes in technology and make sure that students are prepared?

What is Computer Science?

Computer Science is an integrated field of study focused on the practices, applications and tools of computation. It is comprised of the following four categories:

- **Computer Literacy:** Broad understanding of computer and information systems; what they are comprised of, the basics of how they work, how they affect our lives, and ethical implications. Ultimately, computer literacy enables students to be creative problem-solvers and innovators with technology rather than passive consumers of technology.

  Computer literacy encompasses the following sub-categories:

  - Technology literacy: What is technology? How is it used to improve our lives? What are challenges and problems created by the use of technology?
  - Information/digital literacy: What is information or data? How do we collect, organize, analyze and share it? What are benefits and challenges of living in a data-rich world? What is digital citizenship, and what are attributes of a good digital citizen?
  - Basic computing skills: What basic skills are necessary for effectively using computing tools? For example: keyboarding, word processing, creating/naming/saving files, using a web browser.
  - Basic understanding of computing hardware: What are common elements of computing hardware? How does hardware interact with software? What are design considerations for hardware?

- **Computational Thinking:** At its core, computational thinking is problem solving through the application of skills like abstraction, logical/algorithmic thinking, and problem decomposition. Thus, it has a lot in common with other fields of study, but also retains distinctive elements specific to the field of computing. ISTE and CSTA break down CT in the following ways:

  - Formulating problems in a way that enables us to use a computer and other tools to help solve them
  - Logically organizing and analyzing data
  - Representing data through abstractions such as models and simulations
  - Automating solutions through algorithmic thinking (a series of ordered steps)

- Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources
- Generalizing and transferring this problem solving process to a wide variety of problems

- **Computer Programming:** Programming or coding allows us to put machines to work on our behalf. There is a myriad of programming languages and approaches as well as real-world applications of it, such as robotics, data analytics or gaming. Considerations of programming include:
  - Which language is most appropriate for the purpose?
  - Logic vs. syntax/semantics
  - best practices (pseudocode, flowchart, self-directed learning) syntax/semantics,
  - what are the tools (IDEs, SDKs, APIs)
  - What are approaches for managing the developing of software (i.e. systems development life cycle)?
  - What is the role of a programmer or coder within the larger task of software development?

- **Computing Practices and Dispositions:** Like many fields, computing requires mastery of various soft, or 21st century, skills. ISTE and CSTA identify the following:
  - Confidence in dealing with complexity
  - Persistence in working with difficult problems
  - Tolerance for ambiguity
  - The ability to deal with open ended problems
  - The ability to communicate and work with others to achieve a common goal or solution

  We add the following:
  - Curiousity
  - Creativity and innovation
  - Project Management
  - Design thinking - working for a client

RTTT K-12 CS Framework Guiding Resources

- Computer Science Teachers Association.
    - "Computer Science Begins in K-8." https://csta.acm.org/Curriculum/sub/CSK8.html 2005.
    - "CSTA K-12 Computer Science Standards". https://csta.acm.org/Curriculum/sub/K12Standards.html 2005.
    - Wing, J. M. (n.d.). Computational Thinking. https://csta.acm.org/Curriculum/sub/CurrFiles/WingCTPrez.pdf 4 March 2011.
- Code.org https://code.org/ 2015.
    - "Colorado." https://code.org/promote/co 2015.
    - "Making Computer Science Fundamental to K-12 Education: 8 Policy Ideas." https://code.org/files/Making_CS_Fundamental.pdf 2015.
- "Coding School for Kids." Information Week: Government. http://www.informationweek.com/government/leadership/coding-school-for-kids-/a/d-id/1306858?f_src=informationweek_informationweek_mostpopular_fornewsletters&_mc=NL_IWK_EDT_IWK_daily_20140909&cid=NL_IWK_EDT_IWK_daily_20140909&elq=bb93618ec4a1462c8ece5deba6867993&elqCampaignId=8086 2 Sept. 2014.
- Common Sense Media. https://www.commonsensemedia.org/ 2016.
- Computing at School. http://www.computingatschool.org.uk/ 2016.
- "Cybersecurity Jobs 2015." Burning Glass Technologies Research. http://burning-glass.com/research/cybersecurity/ 2016.
- "Future of Computer Science." Tata Consultancy Services. http://www.tcs.com/Insights/Pages/Strategies-Computer-Science-Education-US.aspx 2016.
- "High School Computing: The Inside Story." Institute for Mathematics and Computer Science. https://www.eimacs.com/blog/2011/12/learn-computer-programming-without-complicated-syntax/ 22 Dec. 2011.
- International Society for Technology in Education.
    - "Operational Definition of Computational Thinking for K-12 Education". http://www.iste.org/docs/ct-documents/computational-thinking-operational-definition-flyer.pdf?sfvrsn=2 2011.

    - "Standards for Computer Science Educators." http://www.iste.org/standards/ISTE-standards/standards-for-computer-science-educators 2016.

- "The Key to Growth? Race with the Machines." Erik Brynjolfsson. TED Conferences, LLC. Feb. 2013 https://www.ted.com/talks/erik_brynjolfsson_the_key_to_growth_race_em_with_em_the_machines?language=en. 15 Dec 2015.

- "Landscape of K-12 Computer Science Education in the U.S." Gallup, Inc. http://csedu.gallup.com/home.aspx 2016.

- National Center for Women and Information Technology. https://www.ncwit.org

    - "How do you Retain Women Through Inclusive Pedagogy?" https://www.ncwit.org/resources/how-do-you-recruit-or-retain-women-through-inclusive-pedagogy/how-do-you-retain-women
    - "Framing a Supportive Classroom Climate." https://www.ncwit.org/resources/how-do-you-recruit-or-retain-women-through-inclusive-pedagogy/framing-supportive-classroom

- National Curriculum in England: Computing Programmes of Study. https://www.gov.uk/government/publications/national-curriculum-in-england-computing-programmes-of-study 11 Sept. 2013.

- "One Million Cybersecurity Job Openings in 2016." Steve Morgan. Forbes Magazine. http://www.forbes.com/sites/stevemorgan/2016/01/02/one-million-cybersecurity-job-openings-in-2016/#4b5a8c527d27 02 Jan. 2016.

- "The On-rushing Wave." The Economist. http://www.economist.com/news/briefing/21594264-previous-technological-innovation-has-always-delivered-more-long-run-employment-not-less 18 Jan. 2014.

- "U.S. Smartphone Use in 2015." Aaron Smith. Pew Research Center: Internet, Science & Tech. 01 April 2015. http://www.pewinternet.org/2015/04/01/us-smartphone-use-in-2015/ 15 Mar 2016.

- "Web Developer." U.S. News and World Report. http://money.usnews.com/careers/best-jobs/web-developer 15 Mar 2016.

Pathways in Technology Early College High School (P-TECH) is a new type of school that brings together the best elements of high school, college and the professional world.

Offered at Skyline High, it is a model that allows students to earn a high school diploma, as well as a no-cost Associates of Applied Science degree in Computer Information Systems from Front Range Community College. This program includes significant internship and mentorship opportunities with IBM, giving students a head start on their career after completing the program. Students enroll in 9th grade and complete the program in 4-6 years.

PREPARING STUDENTS FOR 21ST CENTURY CAREERS

- P-TECH will focus initially on computer information systems with focus options in programming and web development.
- P-TECH students will be allowed to matriculate through the 14th grade.
- Students in P-TECH will graduate with a high school diploma and an associate's degree from Front Range.
- P-TECH students will also receive mentorship and internship opportunities with IBM, and IBM has committed to offer job interviews to all graduates of our P-TECH school.
- </> SVVSD, FRCC and IBM will work together to align the curriculum to meet the skills needs of the IT industry and identify pathways to completion of a 4-year degree at Colorado Universities.

APPLY NOW TO BE A PART OF COLORADO'S INAUGURAL P-TECH CLASS

SHS.SVVSD.ORG/PTECH

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P-TECH
PATHWAYS IN TECHNOLOGY EARLY COLLEGE HIGH SCHOOL

EARN A NO-COST ASSOCIATE'S DEGREE IN COMPUTER INFORMATION SYSTEMS

Starting in 2016 at Skyline High School, SVVSD has entered into a cooperative agreement with Front Range Community College (FRCC) and IBM to give St. Vrain students the opportunity to graduate with a high school diploma and Associate of Applied Science (AAS) degree in 4-6 years.

P-TECH will initially offer a pathway in Computer Information Systems (CIS) and the district will support concurrent enrollment during grades 9-12. Students can receive dual credit from St. Vrain and Front Range.

Along with college courses, students will receive mentorships and internships through IBM to provide real-world experiences to supplement their academic coursework.

Students must apply for the P-TECH program and will begin coursework in the 9th grade. For 2016, there are 50 spots available in the P-TECH program at Skyline - the first cohort in the state.

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FRONT RANGE COMMUNITY COLLEGE

IBM

Pathways to Information Technology

From high school student to tech support specialist

Tech1

Intro to IT: A+ Certification

CompTIA Level One

A comprehensive, cross-platform overview of tech support knowledge. This course is designed for 9th and 10th graders, and those new to computer use, support, security, and networking. A+ certified technicians average a $35k starting salary.

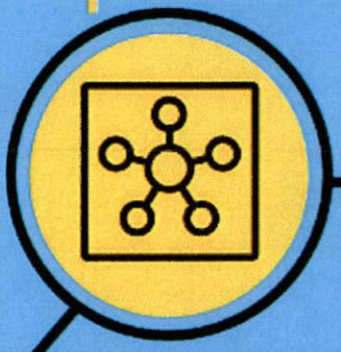
Tech2

Mac Support Certification

Apple Certified Mac Technician: ACMT

ACMT software and hardware curriculum is only available to Apple Authorized Service Providers (AASPs). SVVSD offers this curriculum in order to hire students for our Tech Lab, and to prepare them to work in college IT departments, for AASPs , and for Apple Inc. ACMTs start at around $40k.

Co-Op & Tech Lab



Professional Experience & Advanced Study

Self directing learning and development

Co-op and Tech Lab give students the opportunity to receive class credit and their first salary as an IT professional. Students have access to Cisco Networking curriculum, customer service opportunities, and SVVSD district technology staff (DTS) and projects.

The Innovation Center of St. Vrain Valley Schools
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Innovation Center Tech Team

In the Spring of 2014 The Innovation Center welcomed our first class of ACMT students. In less than two years we have expanded student success, increased course offerings, and placed graduates within third-party service centers, university tech departments, and Apple Retail.

Students Certified

In the first two years we have certified 53 student technicians, out of approximately 215 who have attempted the curriculum.

Customers Helped

After opening Tech Lab for the employees of SVVSD we have helped 250 customers in upgrading and repairing their Macs, or moving from older Macs to new ones.

Devices Setup

During two Tech Lab summers we have deployed over 15,000 iPads, Chromebooks, and MacBook Pros for District Technology Services.

Macs Fixed

Student technicians have logged just under 900 repair-hours, both working on customer computers and practicing on take apart machines.

Graduates Placed

We have placed two classes of technician graduates. One works for Apple Retail, two for third party repair centers, and 19 for their university IT departments.

Past & Future

We would like to expand our student capabilities, have access to Apple mentoring, and train our students on the newest Apple technology.

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