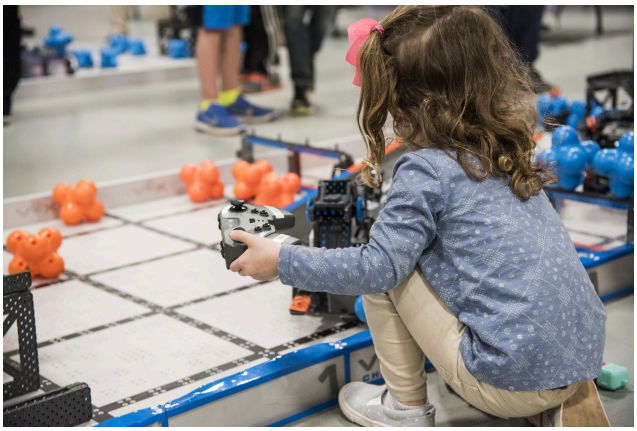
ST. VRAIN VALLEY SCHOOLS
academic excellence by design

Robotics by Design

A Framework for Engaging, Challenging and Transformative 21st Century STEM Education



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SECTION ONE:

Vision, Rationale, Mission and Values

Vision: Our vision is to develop long-term, sustainable, equitable and high-quality robotics programming in SVVSD. We want to inspire educators, students and community members by providing engaging, challenging and transformative robotics experiences, both during and outside of the school day. Through this, we hope to demonstrate the value of robotics in developing motivated, skilled and future-ready students capable of competing on the global stage.

Rationale: This strategic plan makes the case that robotics should be at the center of our district's STEM initiative for two key reasons: first, it provides a very efficient way to meet our district's STEM by Design goals; secondly, it comprehensively prepares students to be future-ready for post-secondary success and provides them with maximum competitive advantage.

Connections to STEM by Design:

- Integration: Robotics is a highly integrated field incorporating a wide range of skills and knowledge. Participating in robotics provides students with a comprehensive, integrated STEM education.
- Problem-Solving: The design and use of robotics systems is inherently an iterative process that requires students to identify and solve multiple problems. The challenges are authentic and meaningful, and students cannot pretend to solve them.
- 21st Century Skills: Because of its integrated nature, robotics regularly requires students to work on teams. In turn, students have the opportunity to develop essential skills like collaboration, communication, project management, persistence, creativity and adaptability, all qualities post-secondary stakeholders regularly identify as key attributes they look for in candidates.
- Personalized Learning: Because robotics is such a diverse field, each student has the opportunity to experience it through a personalized lens. They may play

a role on a team best suited to their strengths; develop expertise in a field related to personal interests; and demonstrate competency through multiple ways. Robotics provides students with considerable voice and agency.

- Connection: Again because of its integrated nature, robotics naturally connects students with other people, places and professions.

Future-Readiness:

The 2017 Colorado Talent Pipeline Report states, "*While no one can predict the future, one thing we know for sure is that the workplace in Colorado will continue to change. While some jobs are being automated, many are requiring increasingly higher levels of technological literacy to operate more advanced systems and procedures. Employers highly value both technical and professional competencies, and in recent decades, fields experiencing job growth are requiring cognitive skills as well as social skills that are both high level. Perhaps more than ever before, it is important for Coloradans of all ages to maintain a fluid skills mindset, as jobs are evolving faster than ever due to technological innovations*."

This excerpt demonstrates the value of robotics education in preparing students directly for careers in related fields as well as for non-robotics fields. Robotics develops both "technical and professional competencies" as well as a "fluid skills mindset". Because robotics is a highly integrated field, students are routinely exposed to various technical skills, are required to develop expertise is multiple skills in order to successfully complete authentic tasks, and hone soft skills like collaboration, communication and persistence as they complete their work. Robotics also naturally supports student-driven and inquiry-based learning.

The question is not whether or not students should enter a robotics-related profession; rather, it is, how does robotics serve as a entry point that puts students on a pathway towards a rewarding, viable future that connects with their individual strengths and interests.

Mission: In order to ensure that every student in the district has access to high-quality robotics opportunities, we will:

- Establish a PK-12 framework of robotics programming throughout the district aligned with the district vision and articulating what robotics looks like at all grade levels
- Develop, implement and refine high-quality, standards-based curriculum in collaboration with practicing educators and professionals in the field
- Develop and deliver high-quality professional development
- Educate and train stakeholders (teachers, parents, school board and administrators, community members, etc) on an on-going basis
- Develop an effective leadership group comprised of multiple stakeholders
- Develop and build partnerships with key external stakeholders
- Continually assess the effectiveness of curriculum and tools used in this implementation
- Develop a sustainable, long-term and equitable structure that addresses concerns such as finance, transportation, and access to resources
- Stay current in a continuously changing discipline

Values: Our vision and mission are based on the following values:

- Inclusivity and Equity: Robotics is for everyone.
- Mentorship: Expertise matters and helps elevate the quality of learning experiences for our students and teachers
- Achieving Excellence: Robotics programming should motivate every student to seek and achieve excellence.
- Relevancy: Authentic learning matters; robotics leads STEM education in providing learning experiences grounded in real-world connections.
- Personalized Learning: Every student deserves the opportunity to be successful and to have learning relate to their personal interests and abilities.
- Healthy Competition: The global economy is highly competitive. Having a healthy relationship to competition builds students' confidence and empowers them to be proactive, ethical participants in a competitive world.

SECTION TWO:
SVVSD Pillars of Robotics

Below is an overview of the skills, knowledge and dispositions students develop through robust, effective robotics education.

21st Century Skills: Communication, collaboration, persistence, creativity, taking initiative, project management and adaptability are keys to success in a diverse, fast-paced 21st century. Robotics cultivates all of these by requiring students to work in teams, tackle ambiguous and challenging tasks, and accept ownership of their experience.

Engagement: A 2015 Gallup poll revealed that large numbers of students, particularly at the high school level, are not engaged with their education. Engaging students in learning is critical for preparing them for a dynamic future. Engagement is more than just having fun: it is about intellectual and emotional challenge, novelty, personal choice, and relevancy. Engagement through robotics motivates, empowers and inspires students.

Authentic Learning: Learning should be relevant to life. It should encourage the meaningful application of critical thinking to real-life problems that matter to students. Competitive robotics provides this opportunity for many students by requiring them to solve challenging problems that interest and challenge them.

Post-Secondary Preparation: The 21st century economy has been transformed by technology. The best career opportunities often require skills in computing, engineering and science. Participating in competitive robotics introduces students to many of these fields and helps build up their 21st century tool kit by developing skills like computer-aided design, programming, math, electronics and more.

STEM Literacy: STEM (science, technology, engineering and math) education is the new literacy for the 21st century. Active participation in this world requires more than the standard literacies. It also requires mastery of STEM content and skills in order to understand and tackle

21st century problems. Being an integrated STEM field, robotics provides an ideal STEM education that works for all students.

Innovation and Entrepreneurship: Having an original idea to solve a challenging problem is one thing; knowing how to maximize the economic benefits of this opportunity is another. Innovation and entrepreneurship go hand in hand; robotics cultivates both. Students find and develop innovative solutions to difficult problems, and they have to articulate these to others through presentations and effective documentation of their work.

Competitive Advantage: Positive experiences of competing with others empowers and strengthens children as well as prepares them for the rigors of 21st century life. Students learn to set their own goals, own the responsibility of working to realize them, manage the emotions that competition creates, and harness the resources necessary for success. They understand what it means to be both a good loser and a gracious winner, and build up their capacity to commit themselves to meaningful goals. In this way, competition becomes a means to an end rather than an end in itself.

SECTION THREE:

Key Terms

Robotics: An integrated field of engineering involving the design, construction, testing and deployment of robots. Robotics is comprised of multiple disciplines, including (but not limited to): mechanical engineering, electrical engineering, computer science, mathematics, and physics.

Robot: A man-made machine capable of interacting with its environment to accomplish tasks humans cannot or do not wish to do. A robot perceives its world through multiple sensors, processes that input to make decisions, then acts, either autonomously or teleoperation, based on these decisions.

SECTION FOUR:

SVVSD Robotics Framework (in progress)

Robotics Standards

- **Design and Fabrication:** Design and Fabrication involves identifying the problem to be solved, using design specifications, researching solutions, developing and representing ideas for a solution, and creating prototypes.

- **Electro-Mechanical:**

- **Applied Engineering:** Applied engineering involves justifying and evaluating design choices with relevant science, math, and technical expertise; developing and using manufacturing processes with consideration of available resources (time, cost, materials, etc); and an understanding of systems integration (how all parts/subsystems work together).

- **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: Computational Thinking, Computing Systems and Networks, Computer Programming.

- **Essential Skills:** Non-technical skills essential for success in career and life. Essential skills for robotics includes: project management, personal skills, entrepreneurial skills, civic/interpersonal skills, teamwork, and professional skills.

Example PGCs for Standard One

Standard One Definition	
Design and Fabrication involves identifying the problem to be solved, using design specifications, researching solutions, developing and representing ideas for a solution, and creating prototypes.	
Prepared Graduate Competencies (PGCs)	
PGC 1	Develop a comprehensive problem statement based on client interactions and needs, team-driven requirements and needs, and/or greater context of the problem environment and audiences.
PGC 2	Formulate and apply design specifications based on problem identification, industry codes and regulations, and available resources (money, time, materials, etc.)
PGC 3	Generate a wide range of design solutions based on prior experience, research, etc.; Represent design solutions utilizing industry standard methods (i.e. 3D modeling, orthographic drawings, etc.)

PGC 4	Evaluate designs based on design specifications, and choose most viable design solution(s) to prototype.
PGC 5	Construct prototypes, and respond to testing data, using industry standard tools (i.e. C.N.C. Machines, 3D Printers, laser cutters, etc.), following all safety regulations.

SECTION FIVE:

Proposed Pathways

As this strategic plan develops, it should align with the most current, cutting-edge and relevant post-secondary work found in industry and higher education. The following proposed pathways have been developed with this criteria in mind and should therefore be reviewed every 3-4 years to ensure relevancy.

Pathway Components: Each pathway will be comprised of the following four components: curricular, extracurricular, work readiness and post-secondary pathways.

- **Curricular:** Opportunities during the school day.
    - Integration: How robotics supports and connects to existing curriculum at all levels. *Example: Gear ratio connects to math and science standards.*
    - Enhancement: How aspects of robotics provides depth to specific focus programs. *Example: Electronics support aeronautics and biomedical engineering.*
    - Elective Classes: Elective offerings, particularly at the secondary level, have been transformed by robotics and computer science. These classes are one of the best ways to introduce a wide range of students to these fields as well as to ensure equitable access.
    - Advanced classes: Courses that are difficult to offer at any one school can be provided through the Innovation Center and/or Career Development Center. *Example: Advanced manufacturing.*
    - Concurrent enrollment: Opportunities to take college-level classes through post-secondary partners should be regularly available to students. *Example: Upper-division math.*
- **Extracurricular:** Opportunities outside of the regular school day.
    - Apprenticeships, internships and tours at local businesses and universities
    - Innovation Center project teams
    - Lecture series and guest speakers

    - Events such as National Robotics Education week and SVVSD Robotics Showcase
    - Exploratory Clubs through Community Schools
    - Competitive clubs (VEX, BEST, FIRST, MATE)

- **Work Readiness/Industry certifications:** Because robotics incorporates a variety of fields, it offers multiple opportunities for students to earn industry certifications. Possible areas for certification include electronics, robotics operations and maintenance, robotics vision, autonomous systems, and artificial intelligence.
    - Examples:
        - Solid Works CAD certification
        - FANUC Robotic Vision certification

- **Post-secondary pathways:** While there are very few academic disciplines exclusively focused on robotics, there are numerous ones which incorporate robotics. These include 2-year and 4-year degrees aligned to programs at both community colleges and state universities. The robotics pathways below offer more detail on each.

Proposed Robotics Pathways:

- **Automation/Industrial:** An industrial robot 'is a robot system used for manufacturing' (Wikipedia). An automated system is pre-programmed, which allows it to operate autonomously using various sensors (such as vision, touch) and actuators. They have a wide range of motion and are capable of lifting and manipulating a wide range of object types and sizes. They are used to accomplish a wide range of tasks, including manufacturing, welding, sorting (pick and place) and others. One of the newest developments in this field is cobots, or collaborative robots, which work alongside humans rather than simply replace them. Safety is a key concern in this field, as is the displacement of human workers as a result of the automation of tasks.

- **Telerobotics (Exploratory/Search-and-Rescue):** One of the main functions of robots is to accomplish tasks humans cannot or do not wish to do. Exploring distant, dangerous or inaccessible locations is one example; responding to disasters or

dangerous situations is another. These kinds of robots are routinely used for marine and space exploration, searching for victims of a building collapse, or diffusing suspected bombs. There is considerable overlap of this branch of robotics with others, particularly autonomous systems and bio-robotics.

- **Human-Robot Interaction:** As robotics becomes more closely integrated into daily life, such as in industry, hospitals, schools, and entertainment, it is increasingly important to understand the way humans interact with these devices. A focus on human-robot interaction will prepare our students for a world in which they work side-by-side with robots on a daily basis. According the the IEEE's Human-Robot Interaction committee, robots used in these environments "*must have human-oriented interaction skills and capabilities to work with us as teammates, learn from us or teach us, as well as communicate with and understand us.*"

- **Autonomous Systems:** An autonomous system is one in which robotic devices function with a high-degree of autonomy, interacting with their environments and independently making decisions and taking actions based on this interaction. Fields which are strongly affected by this field of robotics include transportation (self-driving cars), military (drones), space exploration (Mars Lander) and agriculture (irrigation and harvesting). This branch of robotics strongly relates to the field of artificial intelligence and machine learning.

- **Bio-robotics:** A new and broad field of robotics that explores and identifies ways that mechanical systems can be modeled on biological ones. This kind of biomimicry inspires new designs and materials that can be used in robotics. It also explores the intersection of technology and biology in fields such as prosthetics, soft robotics, robotic surgery and cybernetics.

SECTION FIVE:

Strategic Goals

1-Year: By June 2019

- 2 of 5 Robotics pathways are fully developed (see Pathway components)
- District robotics logic model is completed
- District leadership team (comprised of both internal and external stakeholders) is formed and has met on a regular basis
- Initial draft of PK-12 Robotics Framework is completed
- Resource analysis is completed; initial proposal for resource bank is finished
- Current robotics opportunities (i.e. VEX program, FIRST robotics) continue to grow
- Professional development opportunities expand

3-Year: By June 2021

- All current robotics pathways are fully developed (see Pathway Components)
- Final draft of PK-12 robotics framework is completed and reflects vertical alignment to post-secondary opportunities and to existing curriculum standards
- Robust professional development opportunities are offered on a routine basis, both through SVVSD OPD and through district partners (i.e. Sparkfun); coaching for teachers is regularly available.
- All SVVSD students have a meaningful robotics experience 1x a year (i.e. via CSEd Week, National Robotics Week, robotics unit in a class, after-school robotics club/class)
- All schools offer in-depth robotics opportunities (curricular and extracurricular) to students seeking them.
- Robotics resource bank is built up to support full implementation of Framework and Robotics Pathways