STEM Education and West Linn-Wilsonville School District: An overview and framework for development

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Executive Summary

The West Linn-Wilsonville's learning communities of great thinkers will use science, technology, and mathematics to engineer solutions to problems for the world. STEM education supports the learning and development of essential, innovative, creative and foundational skills to support these learning communities of great thinkers and thoughtful global citizens. The District's STEM education initiative considers the following elements.

Best Practices and Instructional Leadership. The District is exploring studio and lesson study models of professional development to support effective instructional improvement in mathematics and science across all levels. In these models, teachers collaborate and study together in order to understand best instructional practices in their disciplines, deepen their familiarity of state and national standards in content areas, and give and receive feedback during teaching observations to improve instructional practices and better integrate STEM disciplines to enhance student learning. These professional learning communities are essential to expanding our collective understanding of STEM education and how to create meaningful learning experiences for students.

K-12 STEM Experiences. State and national standards in STEM disciplines provide important frameworks for best practices and the scope and sequence for content across the grade levels. Using these frameworks and curricular resources is important to develop integrated STEM education experiences for kids and to see commonalities between science, math, engineering and technology practices, such as asking question, defining problems, and using models. The scope and sequence of K-12 experiences considers the diverse ways that students engage in STEM education and areas for further development. Current and future STEM experiences include school day experiences, after school clubs, independent research projects, and non school day experiences. While every student may not choose to enroll in a STEM related field of study or pursue a STEM career, all students will have the experiences to build the knowledge and skills in STEM disciplines to pursue those pathways if they choose.

Exemplars of STEM Education Programs. The District has many exemplars of STEM education programs currently across the schools and grade levels. These programs and unique learning experiences integrate STEM disciplines in ways that provide hands-on and relevant learning experiences that support innovative thinking and are often supported by community partners or STEM industry professionals. These exemplars set our work apart from other local initiatives and continue to inspire the development of additional STEM programs and experiences.

STEM Learning Spaces and Contexts. The Center for Research in Environmental Sciences and Technologies (CREST) is well positioned to support this larger STEM education initiative through the lens of sustainability and the environment. Grounding STEM education experiences in the environment and the context of sustainable development reinforces our District's mission of supporting great thinkers for the world. The arts also provide an additional context for STEM education. STEAM education provides opportunities to interpret information, thinking critically, and ground student thinking about art in math, science, engineering, and technology practices. Facilities around the District support these unique and diverse learning experiences and contexts, providing not only the physical spaces, but also the tools and resources needed to support meaningful learning for students.

Career and College Readiness. STEM experiences work to deepen student understanding of STEM disciplines while also providing opportunities to develop entrepreneurial oriented skills for both career and college readiness. This includes, but is not limited to, supporting creative thinking and innovative design solutions, mentoring by industry professionals, internships with experts in STEM fields of study, and work experience in STEM settings. Career and Technical Education (CTE) programs also foster skills that are both relevant for STEM fields of study and career paths. The District is working to develop additional CTE programs that provide a unique approach to STEM education, such as a program of study in sustainable agriculture that blends course work with farming.

Community Partners. Fostering new and enhancing existing partnerships to support STEM education is important in collaborating around the development, funding, and mentorship for the District STEM education programs. The District currently works with Oregon Tech, Clackamas Community College, and Oregon State University Extension to provide dual credit offerings and support Oregon Department of Education's 40-40-20 initiatives. In addition, partnerships with METRO and the Cities of West Linn and Wilsonville support real world environmental and community based experiences. The District is part of the South METRO Salem STEM Partnership and gained access to STEM industry and community partners through this network.

Definition and Background on STEM Education

The Oregon STEM Education Initiative proposes the following as a new description of STEM Education:

> *An approach to teaching and lifelong learning that emphasizes the natural interconnectedness of the four separate STEM (science, technology, engineering and mathematics) disciplines. The connections are made explicit through collaboration between educators resulting in real and appropriate context built into instruction, curriculum, and assessment. The common element of problem solving is emphasized across all STEM disciplines allowing students to discover, explore, and apply critical thinking skills as they learn.*[i]

Following research and data collection on STEM education, the Oregon Department of Education further articulated the needs for STEM education in our schools:

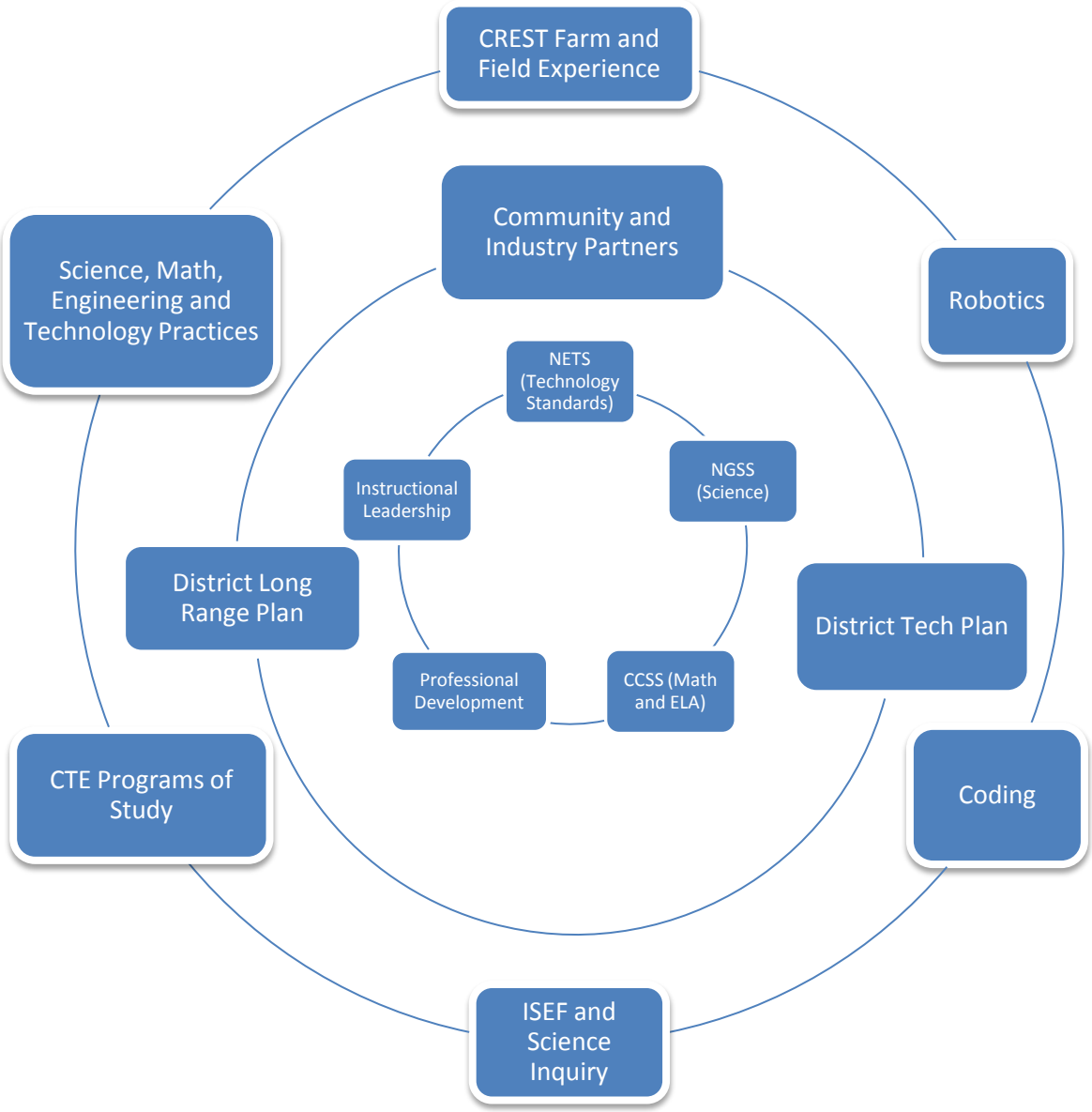
> *Our nation, state, and local communities face challenges that will only be solved with assistance from a well-trained and STEM educated citizenry. The growing world demand on energy has created a need to develop new and cost effective resources. An aging population will require increased services from the health care industry. Finally, driving an economy that thrives on innovation requires a growing number of innovators. Increasingly, the solutions to these problems have required a coherent and coordinated effort from all four disciplines in STEM. Many of the problems faced will require some form of engineered solution. However, these solutions will rely heavily on the knowledge base in science and mathematics as well as the analytical power of sophisticated technological tools*[ii]*.*

District Mission, Vision Themes and STEM Education

The core elements of STEM education are inherent in the District's vision themes and mission question: *How do we create learning communities for the greatest thinkers and most thoughtful people…for the world?* The West Linn-Wilsonville School District envisions a school learning community which:

1. Demonstrates personal and academic excellence;
2. Provides a personalized education to improve student performance;
3. Establishes community partnerships and expands the classroom beyond the school;
4. Creates a circle of support for each student;
5. Educates the whole person—intellectually, emotionally, physically, and ethically;
6. Integrates technology in daily learning.

Great thinkers will use science, technology, and mathematics to engineer solutions to problems for the world. A personalized education for all students that is inquiry-based, collaborative, and integrates technology in teaching and learning is important in providing real world connections to STEM disciplines. This approach allows teachers and students to extend learning from the classroom through field and community based experiences. Similarly, integrating technology into daily instruction and learning provides students with tools to make connections to and between science, math, and engineering disciplines. Considering a STEM program that is grounded in the District vision themes and the mission question provides a framework for a K-12 continuum that identifies milestones and learning opportunities for students to advance in STEM education. STEM education in the District, as described in the diagram below, integrates many existing programs, while also planning for expansion and the establishment of new learning opportunities and experiences for students. Practices in science, math, engineering, and technology are important for not only STEM education, but also supporting life long learners and thoughtful global citizens.


CREST Farm and Field Experience
Community and Industry Partners
Science, Math, Engineering and Technology Practices
Robotics
NETS (Technology Standards)
Instructional Leadership
NGSS (Science)
District Long Range Plan
District Tech Plan
Professional Development
CCSS (Math and ELA)
CTE Programs of Study
Coding
ISEF and Science Inquiry

Best Practices and Instructional Leadership

The District sees the value and effectiveness in engaging teachers and administrators in a studio based, lesson study professional development experience. The District is exploring an approach for professional development in all STEM disciplines that is similar to what is used for instructional improvement in mathematics and literacy. A studio experience provides an opportunity to engage all teachers in a given disciplines or at a given grade level to study together and connect standards with instructional practices. It also allows teachers to work to identify commonalities in the practices and standards within science, math, engineering and technology and strengthen and create integrated STEM curriculum. Defining and documenting best practices in a discipline and then engaging in a year-long study of instructional strategies employed in the classroom, connections to curriculum, and assessment of student learning is critical in making professional development meaningful and relevant. In addition, the District sees this studio and lesson study approach as an important opportunity to explore the connections between STEM disciplines, a critical area for teachers to explore to make STEM education relevant and transdisciplinary.

Professional Learning Communities and Lesson Study in Primary Schools

The Center for Research in Environmental Sciences and Technologies (CREST) staff and District administrators are well positioned to work with teacher teams at primary schools to form professional learning communities (PLCs) at individual grade levels around the best instructional practices and standards within STEM disciplines. Teachers will collaborate with their PLCs and a STEM expert during an initial workshop that dissects best instructional practices and the standards based approach to STEM education. PLCs will then engage in deep lesson study, in which teachers review best instructional practices in science and work to develop lessons to implement in their classrooms. In subsequent years, PLCs will integrate the work from math studio to develop multidisciplinary lessons. Over time, studio work with technology and engineering practices will be folded into the PLC work and explorations to truly integrate STEM education into student learning. The PLC will provide feedback as they observe each other teach the lessons that they will create together to highlight best instructional practices. PLCs will either reviewing tapes or making first hand observations during class times depending on funding and scheduling. One example of organizing and supporting this type model is described below:

Year	School Year	Participants	Focus	Funding Requirements
1	2013-2014	STEM Coordinator, school principals, school ICs	Understanding the lesson study model	Subs for a District wide leadership STEM workshop in winter 2014
2	2014-2015	School ICs, grade level teams K-2	Lesson study for science	Subs for teachers to watch each other teach and meet during planning times at least 3-4x per year
3	2015-2016	School ICs, grade level teams 3-5	Lesson study for science	Subs for teachers to watch each other teach and meet during planning times at least 3-4x per year
		Grade level teams K-2	PLC during planning times and staff meetings and professional growth Wednesdays to continue lesson study work in less formal setting	None.
4	2016-2017	School ICs, grade level teams K-5	Lesson study for integrated math and science	Subs for teachers to watch each other teach and meet during planning times at least 3-4x per year
		Grade level teams 3-5	PLC during planning times and staff meetings and professional growth Wednesdays to continue lesson study	None.

			work in less formal setting	
5	2017-2018	School ICs, grade level teams K-5	Lesson study for integrated math and science	Subs for teachers to watch each other teach and meet during planning times at least 3-4x per year

Lesson Study with District Middle Schools

The District will support an intensive lesson study model, aligned with what is described above for the primary level, with all middle schools in the District beginning in the early months of 2014. Based on the success from recent studies and programs in middle schools in Northern California, the District will support a lesson study model for instructional improvement with both math and science teachers. One example of organizing and supporting this type model is described below:

Year	School Year	Participants	Focus	Funding Requirements
1	2013-2014	STEM Coordinator, MS principals and assistant principals, MS science teachers	Understanding what is a lesson study model and best practices in science	Subs for a District wide leadership STEM workshop in winter 2014
2	2014-2015	Separate PLC of school/ grade level team of science teachers	Year long workshop on NGSS and CCSS and understanding math and science practices	Extra pay for workshops or additional PLC times??
3	2015-2016	Grade level teams for science teachers	Lesson study for science	Subs for teachers to watch each other teach and meet during planning times at least 3-4x per year
		Grade level teams for math teachers	Lesson study for math	Subs for teachers to watch each other teach and meet during planning times at least 3-4x per year
4	2016-2017	Grade level teams for both science and math teachers	Lesson study for integrated math and science	Subs for teachers to watch each other teach and meet during planning times at least 3-4x per year
		STEM Coordinator, MS principals and assistant principals, MS science and math teachers	District wide PLC for MS science and math teachers	Subs for a District wide STEM workshops and planning and observation times between Middle Schools
5	2017-2018	School teams with both science and math teachers to work across school departments	Lesson study for integrated math and science	Subs for teachers to watch each other teach and meet during planning times at least 3-4x per year

Integrated High School STEM Experiences

The District also plans to support an intensive lesson study model with high school teachers as well. The District is continuing to research effective approaches to studio and lesson study models at the high school level, but will base an initial approach on the success seen at the primary and middle school levels. One example of organizing and supporting this type model is described below:

Year	School Year	Participants	Focus	Funding Requirements
1	2013-2014	STEM Coordinator, HS principals and assistant	Understanding what is a lesson study model	Subs for a District wide leadership STEM workshop in

		principals, math and science department heads		winter/spring 2014
2	2014-2015	Separate PLC of school/ department of math and science teachers	Year long workshop on NGSS and CCSS and understanding math and science practices	Extra pay for workshops or additional PLC times??
3	2015-2016	Grade level teams for science teachers	Lesson study for science	Subs for teachers to watch each other teach and meet during planning times at least 3-4x per year
4	2016-2017	Grade level teams for both science and math teachers	Lesson study for integrated math and science	Subs for teachers to watch each other teach and meet during planning times at least 3-4x per year
5	2017-2018	School teams with both science and math teachers to work across school departments	Lesson study for integrated math and science	Subs for teachers to watch each other teach and meet during planning times at least 3-4x per year

CREST Summer STEM Professional Learning Community Experiences

In addition to supporting professional development and instructional improvement in STEM education during the school year, The Center for Research in Environmental Sciences and Technologies (CREST) is well positioned to adopt a studio model during its current Learning on the Go summer programs. This expansion to CREST's current summer programs will allow a diverse population of students to have the change to engage in a STEM summer camp experience, while also providing a weeklong studio type setting for teachers to explore themes of environment and sustainability in STEM education. Groups of teachers will have the opportunity to work with CREST staff, high school and post-high school counselors, and students for a weeklong session of this hybrid STEM professional development and summer camp model. One day per session will occur at the CREST farm site to model instructional practices for garden-based education. In this model, teachers will have the opportunity to observe instructional practices modeled by CREST staff and work in grade level teams to review STEM practices and create integrated place-based and education for sustainability themed STEM lessons. Teachers will observe peers and provide feedback in this condensed lesson study experience. One example of organizing and supporting this type model is described below:

Participants: 10-15 teachers per session, HS and post-HS counselors, and CREST staff
Funding Requirements: Stipend for teachers, CREST staff, and HS and post-HS counselors during each session

Session	Month/Week	Grade Level
1	End of June	K-2
2	Beginning of July	3-5
3	Middle of July	6-7
4	End of July	7-8
5	Beginning of August	3-5

Books and Supplemental Resources

Below are some lists of recommended websites and books to integrate into presentations, workshop or additional reading during professional development in STEM education.

Websites

- Videos about teaching science from UK
- TedTalk on Teaching Science

- STEM Video games
- Robotics
- Real World Internships and Career Readiness
- Technology integration
- Next Generation Science Standards

Books

- *Lesson Study: A Japanese Approach To Improving Mathematics Teaching and Learning (Studies in Mathematical Thinking and Learning Series)* by Clea Fernandez and Makoto Yoshida
- *Leading Lesson Study: A Practical Guide for Teachers and Facilitators* by Jennifer Stepanek, Gary Appel, Melinda Leong, Michelle Turner Mangan, Mark Mitchell
- *Lesson Study Step by Step: How Teacher Learning Communities Improve Instruction* by Jacqueline Hurd and Catherine Lewis
- *Supporting Grade 5-8 Students in Constructing Explanations in Science: The Claim, Evidence, and Reasoning Framework for Talk and Writing* by Katherine L. McNeill and Joseph S. Krajcik
- *The NSTA Reader's Guide to A Framework for K 12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* by Harold Pratt
- *STEM Lesson Essentials, Grades 3-8: Integrating Science, Technology, Engineering and Mathematics* by Jo Anne Vasquez, Michael Comer, and Cary Sneider

K-12 STEM Experiences

While every graduating student might not choose a STEM related field of study or career after high school, we want to ensure that every student has the creative and critical thinking skills and deep understanding to succeed should they choose a STEM pathway. Being scientifically literate, understanding the essential principles in mathematics, and graduating with meaningful experiences with engineering design and technological understandings are important components of STEM education, college and career readiness, and global citizenship.

State and National Standards

Effective STEM education is grounded in teaching for deep and enduring understanding in all disciplines. We see the Common Core State Standards (CCSS) in Mathematics and English Language Arts, as well as the Next Generation Science Standards (NGSS), as important resources in establishing frameworks for developing a deep understanding and cogitative skills in the STEM disciplines. District administrators, school principals, CREST staff, and teachers continue to work in collaborative groups to unpack and integrate the Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS) into the District's work. Printed in the book *STEM Lesson Essentials*[iii], the table below shows how mathematical, scientific and engineering practices listed in these state and national standards are strongly related. Teachers and administrators continue to identify these commonalities as an initial step to integrate lessons and enhance STEM education across the grades levels.

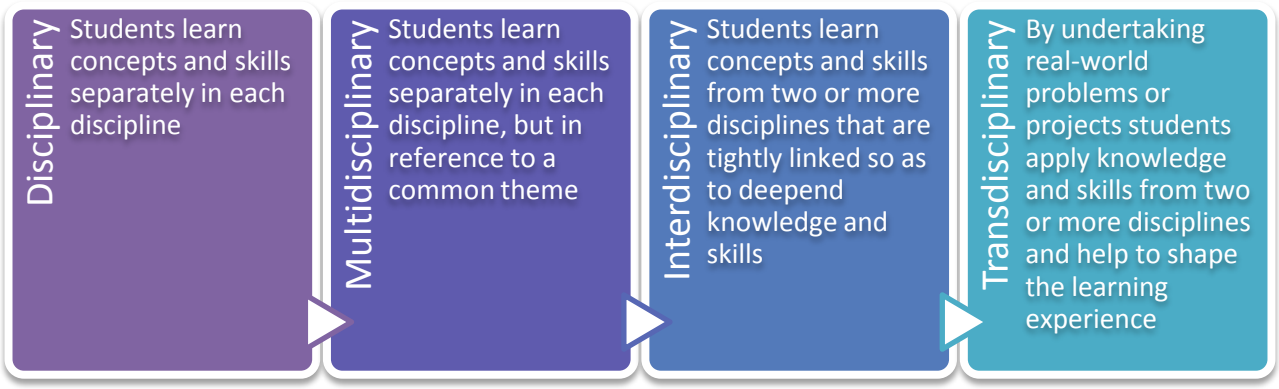
Commonalities between STEM Practices

Scientific Practices (NGSS)	Engineering Practices (NGSS)	Technology (NETS)	Mathematical Practices (CCSS)
Ask questions	Defining problems	Become aware of the web of technological systems on which society depends	Make sense of problems and persevere in solving them
Develop and use models	Develop and use models		Model with mathematics
Plan and carry out investigations	Plan and carry out investigations	Learn how to use new technologies as they become available	Use appropriate tools strategically
Analyze and interpret data	Analyze and interpret data		Attend to precision
Use mathematics and computational thinking	Use mathematics and computational thinking	Recognize the role that technology plays in the advancement of science and engineering	Reason abstractly and quantitatively
Construct explanations	Design solutions		Look for and make use of structure
Engage in argument from evidence	Engage in argument from evidence	Make informed decisions about technology, given its relationship to society and the environment	Construct viable arguments and critique the reasoning of others
Obtain, evaluate, and communicate information	Obtain, evaluate, and communicate information		Look for and express regularity in repeated reasoning

Integrating STEM Disciplines

In the book, *STEM Lesson Essentials*, authors Sneider, Comer and Vasquez explore the relationship between STEM disciplines in teaching and learning. Considering the increasing level of awareness about the importance of STEM education in schools, *STEM Lesson Essentials* provides a continuum that outlines approaches to integrating STEM curriculum. This continuum is an important resource as we think about existing and future K-12 learning experiences and define our goals for STEM curriculum integration across the levels. While the format of the table below is different

from what is published in the book, the figure below using the language and concepts from *Figure 8.6* in *STEM Lesson Essentials*[iv].



Our vision for STEM learning is based on the balance of this continuum of integrating STEM curriculum throughout the grade levels. There is a need to balance deep learning in independent disciplines with transdisciplinary lessons and learning to undertake real world, project based problems to solve through STEM education. STEM experiences vary across the grade levels, providing different opportunities to use real-world problems that students can use when engineering solutions. Considering the scope and sequence for K-12 STEM experiences is important as we think about students building on their understanding in STEM disciplines and having real world and relevant opportunities to reinforce that learning. Working through the lens of the environment and sustainability, as well as providing varied experiences for our diverse student population, the District has thought about how early elementary experiences prepare students for upper elementary and ultimately middle and high school skills and understandings.

Grade Level STEM Goals

The California Department of Education has articulated STEM goals for each grade band at the elementary (K-5), middle (6-8), and high school (9-12) levels. This language, as provided below, will inform the District's thinking about similar goals and experiences within our K-12 STEM education continuum.

Elementary School Grades:

- Provides the introductory and foundational STEM courses that lead to success in challenging and applied courses in secondary grades
- Introduces awareness of STEM fields and occupations
- Provides standards-based, structured inquiry-based and real-world problem-based learning that interconnects STEM subjects
- Stimulates student interest in "wanting to" rather than "having to" take further STEM related courses
- Bridges and connects in-school and out-of-school learning opportunities

Middle School Grades:

- Introduces an interdisciplinary program of study consisting of rigorous and challenging courses
- Continues to provide standards-based, structured inquiry-based and real world problem-based learning that interconnects STEM-related subjects

- Bridges and connects in-school and out-of-school learning opportunities
- Increases student awareness of STEM fields and occupations, especially for underrepresented populations
- Increases student awareness of the academic requirements of STEM fields and occupations
- Begins student exploration of STEM related careers, especially for underrepresented populations

High School Grades:

- Provides a challenging and rigorous program of study focusing on the application of STEM subjects
- Offers courses and pathways for preparation in STEM fields and occupations
- Bridges and connects in-school and out-of-school learning opportunities
- Provides opportunities for student exploration of STEM related fields and careers, especially for underrepresented populations
- Prepares students for successful post-secondary employment, education, or both

Exemplars of STEM Education Programs

The District has many exemplars of STEM education programs across the schools and grade levels. The following descriptions provide a short overview of indicators of STEM education happening in the District. These programs and unique learning experiences integrate STEM disciplines in ways that provides hands-on, real world, and relevant learning experiences for students, often supported by community partners or STEM industry professionals. These exemplars set our work apart from other local initiatives and continue to inspire the development of additional STEM programs and experiences.

CREST Field Experiences

STEM education begins with fostering a sense of wonder and giving students place-based field experiences to have strong connections to the surrounding community. Exposing kids to their environment at the early grades is essential to support curiosity and inquiry about the interaction between STEM disciplines. Expanding field experiences to include a great part of the community and region during the upper elementary and middle school provides opportunities for students to focus and explore those interests. By high school, students have had diverse field experiences and can pursue specific opportunities related to their interests, whether through participation in ISEF (see below), AP classes, or internship experience with the CREST Farm to School site related to sustainable agriculture. In this model, all experiences are informed by and grounded in the CCSS Mathematical Practices, NGSS Scientific and Engineering Practices, and the Big Ideas in Education for Sustainability. Students integrate science and literacy across the grade levels by using the claim, evidence, reasoning and rebuttal framework for talking and writing in science and mathematics. This approach, widely accepted by the science education community, has been heavily researched and written about by Katherine L. McNeil. As such, teachers and CREST staff will continue to work to integrate these practices into instructional practices in science and the CREST field experiences.

Engineering Curriculum

Engineering courses and experiences take different forms across the grade levels. Engineering is Elementary is a resource that the District adopted with its most recent science adoption for the primary level. This curriculum, developed at the Museum of Science (Boston), provides units that integrate literacy and anchor texts with real world engineering design problems. As stated on their website, the mission of Engineering is Elementary "is to foster engineering and technological literacy among ALL elementary-aged children." These units and experiences provide primary school students with experience in engineering design, as an extension of science units and concepts outlined in the NGSS. The Museum of Science (Boston) also develops curricular resources for engineering to be integrated into middle and high school mathematics courses. As primary school teachers implement Engineering is Elementary units, the District will continue to explore *Building Math* and *Engineering the Future* as another opportunity to provide STEM education experiences for middle and high school students.

Described in greater detail below, the District's partnership with Oregon Tech (OIT) also provides an opportunity for high schools students to enroll in OIT's Introduction to Engineering High School Transition course bundle. These college level courses will provide a strong foundation in a diverse range of engineering fields, while also giving students a chance to earn college credit. This partnership is important for our on-going development of dual credit opportunities for students. District teachers plan to work with OIT professors to develop more engineering courses at the middle and high school levels.

Science Inquiry, Research and the Intel International Science and Engineering Fair (ISEF)

Science inquiry and research takes place at every grade level. The interest and curiosity fostered at the younger grades is further supported with formalized inquiry projects and local science fairs at the upper grades. Students entering middle school and high school have a strong foundation in scientific and engineering design and the opportunity to participate in the District's Science Symposium, which then prepares students for the state-level Northwest Science

Expo and Intel International Science and Engineering Fair (ISEF). Inquiry fairs and ISEF provide an opportunity for students to apply their understanding and interest in the STEM disciplines through meaningful inquiry and research projects that are grounded in real world applications. Presenting their research connects students with STEM professionals who mentor their projects and act as judges during the various fair competitions. College scholarships are also available for certain fair awards, making local universities more accessible for students following high school graduation.

Farm to School and Sustainable Agriculture

STEM education in the West Linn-Wilsonville School District has a strong history in the environmental sciences. We ground students' experiences in the natural world around our schools and in the community to provide meaningful and relevant design problems for engineering solutions, connections to science inquiry, and the use of local technologies. The CREST Farm to School site provides a unique opportunity to experience STEM in action. Students work with a resident farm manager and CREST educators on a 10 acre District owned property to understand components of sustainable agriculture. Students design and construct solutions related to the cultivation, harvest, and distribution of produce from the farm site and have opportunities for year round internships to extend their learning in the classroom. A deep understanding in STEM disciplines is required when learning about all of the components of vegetable production and distribution from the farm. Fifth grade classroom field experiences then encourage middle school and eventually high school students to gain relevant and important work and career skills through summer and year round internships at the farm.

US FIRST and LEGO Robotics Programs

Students experience disciplinary core ideas in science, technology, engineering and mathematics when they engage in the District's robotics program. Beginning at the primary level, all second grade students work with engineering design principles and experience authentic inquiry with the LEGO WeDo curriculum. Connected to Next Generation Science Standards, second grade classes explore programming, using models, and engineering design. Building on this universal experience, fourth and fifth grade students are able to participate in the For Innovation and Recognition of Science and Technology's (FIRST) LEGO League teams. These teams form as enrichment classes or after school clubs, working to solve problems commonly faced by scientists and engineers, as well as to build small LEGO robots. Continuing at the middle level, sixth through eighth grade students build on these foundational experiences and continue work and participation with FIRST LEGO League teams. These teams are supported by teachers, schools, and parents and prepare students for competitions. At the high school level, students from Wilsonville and West Linn High Schools combine forces on the District's FIRST Robotics Challenge team. With support from community partners, professional mentors, and a teacher advisor and coordinator, high school students have seen great success on the regional and national stage during these competitions. Through integrated learning in science, technology, engineering, mathematics, students design and build robots to meet certain criteria and functions for local and national competitions. The team's mission, *Building Robots. Building People*, reinforces how students and teachers believe that this team provides a unique opportunity for real world, leadership experiences through the deep understanding of STEM disciplines.

Providing experiences with robotics is important when integrating STEM education into student experiences across the grade levels. Continuing to foster partnerships with local educational providers, industries, and professionals, engage teachers at all levels in professional development around robotics and engineering, and support robotics teams throughout the District is important to the sustained growth of these teams and programs. Robotics programs throughout the District connect to other salient components of the District's STEM education program, such as coding and programming. In addition, robotics connects to the District Technology Plan, which outlines how technology supports teaching and learning for students and teachers at all levels.

Green Building Design and School Buildings

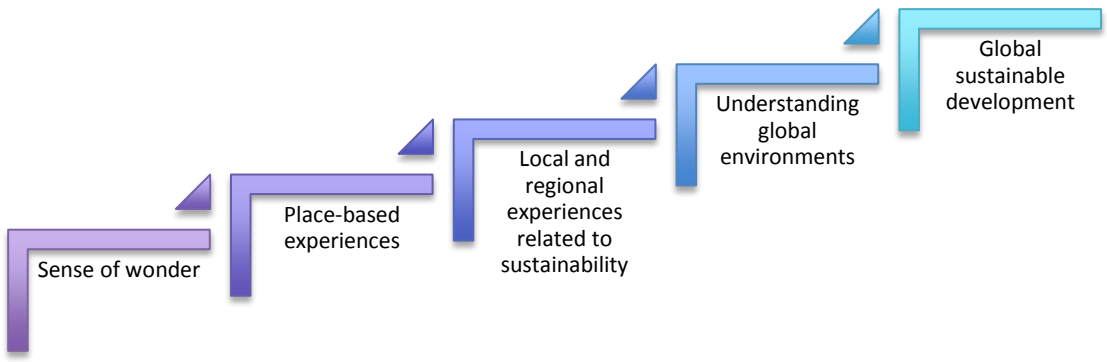
Green building design is an important piece of understanding elements of sustainable development, both at the local and global scale. Students around the District have an opportunity to explore sustainable design features that are demonstrated in buildings within our community. Trillium Creek and Lowrie Primary Schools, which opened for the 2012-2013 school year, are both Leadership in Energy and Environmental Design (LEED) Gold certified schools. This US Green Building Council (USGBC) rating system provides credits for a variety of design features and construction practices within six categories. Gold is the second highest rating. Trillium Creek and Lowrie Primary Schools were designed and built with student learning in mind and both provide opportunities for students and visitors to learn about and continue to tell the story of sustainability. These schools demonstrate a range of green building design strategies, from energy conservation to school gardens. Through partnership with DOWA-IBI Group, the architectural firm that has designed many of schools in the District, middle school students also have a unique opportunity to enter into a design competition as they are tasked with designing a new middle school to meet certain green building criteria. Green building and design is also an important focus and component of high school environmental science courses as students explore the relationship between the built environment and strains on natural resources, urban planning, and energy efficiencies. These themes continue to be important considerations for creating learning experiences for students, but also the Long Range Plan and current and future planning around District facilities, programs, and operations.

STEM Learning Spaces and Contexts

The Environment and Sustainability

With support from CREST, students in the District are engaged in science inquiry and field based experiences in the early primary grades to extend learning from the classroom. Place-based field experiences, garden-based and farm to school related education, and education for sustainability programs support the early development of scientific inquiry and wondering about the world around us. These programs occur both during the school day, as well as in the summer and non-school calendar to provide learning opportunities in science and engineering throughout the year. Highlighting the environmental threads and context within STEM education reinforces the interconnectedness of these disciplines. Transdisciplinary STEM education is necessary to achieve a deep understanding of sustainable agriculture, science inquiry and research, field based experiences involving long term data collection, hands-on science, and the "3 E's" (environment, economy, and equity) of education for sustainability.

Based on current research in the fields of place-based education, environmental education, and education for sustainability, a continuum for student experiences in the environment has emerged. Beginning first with developing a strong sense of wonder and appreciation for the natural world, student experiences build to integrate long-term studies and experiences in the schoolyard and community. Applying that understanding and learning to the larger region and local natural phenomena and resources continues to build an understanding about principles of the natural world that can be applied to global environments. Following focused service-learning experiences at the middle school, concepts and notions of global sustainable development become more attainable for high school students. The diagram below captures and outlines this thinking.



CREST Program Coordinators and the CREST Director work to find community partners and grant opportunities to expand and develop student programs. CREST Program Coordinators are also actively involved with professional development in schools, working with teachers to better understand best practices in teaching science, and the practices and core ideas of the Next Generation Science Standards (NGSS). CREST staff model effective instructional strategies for science inquiry and field based experiences for students, working with teachers to build capacity and instructional improvement. Moving forward, CREST staff will integrate resources and additional trainings about STEM education as an important expansion of their work.

Learning with the Arts and STEAM

The arts provide an important context for STEM education. STEAM education gives students opportunities to think critically, interpret information, and engage other essential mathematic, science, engineering and technology practices. Arts education fosters collaboration between peers, but also with community members and artists in residence. One example of this is that Beauty and the Bridge STEAM project that took place in Wilsonville. During the 2011-2012 school

year, students from primary, middle and high schools in Wilsonville experienced the integration of STEAM disciplines in a community-based project. Following the development and expansion of Wilsonville's commercial area adjacent to the I-5 corridor, there was an opportunity to bridge the two sides of Wilsonville. In collaboration with the City of Wilsonville, students worked with City officials and staff to understand the need for connectivity in walking and biking paths, vehicular safety, and the master plan for the development of this area of Wilsonville. Collaborating and conducting in depth research on native flora and fauna of the North Willamette Valley, students at all grade levels in the Wilsonville schools worked to select various native plants, animals and landscapes for this community art project. With the support of art teachers and artists in residences, students researched, sketched, critiqued and refined their contribution to the project before ultimately painting the 7,200 tiles now installed in the underpass of I-5 at the Wilsonville interchange. Projects like this show how important the arts are in providing a real world context for STEM education.

The arts connect to STEM education also through the notion of artistic, innovative thinking being essential for engineering creative solutions to complex problems. Discussed in greater detail below in the College and Career Readiness section, creative thinking is essential for students when they will need to thinking critically about a problem they have defined, ask questions, and engineer a long-lasting solution.

Learning with Technology

Technology has the potential to change the learning and the learner. In the earliest days with computers in schools, the workbook style activity was transferred to the computer format. Very little changed in the learning, in fact, research showed that basic facts practice, as it was presented in its simple form, did nothing to increase the quick recall of facts. Technology is now widely used by our students for research, close reading and production. Students use the technological tools available to calculate, to read and write, to tap into streams of live information, to communicate with others, and to do so from school and from home.

Teachers and students in West Linn-Wilsonville schools are harnessing the power of graphic organizers for analysis and synthesis. The morphological chart formerly drawn on paper can now be transferred to a database where sorting and analysis take the student to a more complex form of thinking. Digital video, digital music, graphic multimedia presentations are becoming common in our classrooms. When children are invited to make public presentations of complex learning, the products become exemplars for the next student, the next class. In this way, a rising standard of student performance is emerging in the learning community. These multimedia presentations have become more polished and are used more extensively with new production technologies.

Learning with technologies allows children to do what they could not otherwise do. Well designed software coaches children in mathematics. Video sources provide a window to worlds the student cannot visit, a seat in the great lecture halls of the world, and quick reference for review or expansion of concepts. Computer adaptive software allows students to explore mathematics they do not yet understand, test ideas, fail, and construct a useful understanding of the concept. Well designed writing software coaches children through the complexity of written composition. Web quests and research software link questions to resources and help students juggle the use of multiple sources in a recursive research process.

Simulation software allows children to manipulate and tweak the parameters of the variables in complex situations gaining an understanding of the principles of mathematics, science and the social sciences. Design software allows children to take on design challenges in robotics, geometry, graphic arts, art, and architecture. Quick access to references on line allows students to read dense text with more understanding.

Assessment with technology escapes the boundaries of time, becoming timely, personalized, and adaptive. Computer adaptive assessment has greater power to yield useful assessment information for teachers to use as feedback and actionable data to aid in planning. Computer adaptive assessment, particularly in a low stakes environment, has the power to provide students effective feedback on the learning.

Spaces for Innovative

The notion of spaces for innovation, or maker spaces, has generated widespread support within K-12 education. Initially referenced in the launch of the White House's 2009 "Educate to Innovate" campaign, President Obama said, "I want us to think about new and creative ways to engage young people in science and engineering, whether it's science festivals, robotics competitions, fairs that encourage young people to create and build and invent—to be *makers* of things, not just consumers of things."[v] Since then, non-profits such as *Maker Education Initiative* have formed with a mission to "create more opportunities for young people to develop confidence, creativity, and spark an interest in science, technology, engineering, math, the arts, and learning as a whole through making."[vi]

Taking the pulse of this initiative is important for our own thinking about maker spaces in the District. The design for the District's multidimensional libraries and open, flexible spaces support this notion and have already started to support informal spaces for innovation in the primary schools. It will be important to think about the opportunity these flexible spaces provide as our on-going stewardship of District spaces and places and how they support important learning for students. An emerging idea to support this stewardship is to provide garage like spaces around the District. By providing flexible, open and somewhat ill defined places we encourage authentic invention to emerge from student ideas and creative thinking and their desire to create the STEM project that they see as truly innovative.

STEM Education and the Long Range Plan

There are strong connections between the STEM education initiative and the Long Range Plan. Our STEM education initiative supports and helps to frame a portion of the planning for future growth, both for enrollment and facilities, and the long-range operations of the District. Similarly, considering the components of STEM education programs when planning for current and future facilities and District owned property ultimately enhances student learning opportunities in STEM. Whether it is the notion of maker spaces, robotics, ISEF research projects, or farm to school and sustainable agriculture CTE programs, STEM education and our understanding of technology in education will continue to evolve as research in these fields is published. The Long Range Plan remains poised and prepared to support the needs of these initiatives and will be critical for the collective success of STEM education in the District.

College and Career Readiness

The regularly researched idea of supporting creative, entrepreneurial thinking in students of all ages applies directly to STEM education. As we engage in this discussion across curriculum and instruction topics, it resonates strongly with STEM education and the idea of college and career readiness. One of the most documented goals of STEM education is to prepare students to be able to pursue careers within STEM pathways and fields of study. While this aligns with District goals as well, we also inject the idea of entrepreneur-oriented education in addition to this more traditional idea of career-oriented education. Supporting engineering studies, for example, that supports and fosters the creative thinking needed to be innovative about solving problems and finding elegant solutions and engaging the creative brain is essential for all students regardless of their post high school pursuits.

Dr. Yong Zhao of the University of Oregon talks specifically about opportunities to support entrepreneurial thinking as an important component of career readiness. As Zhao writes in his book, *Catching up or leading the way: American education in the age of globalization*, "In the new era, we need more diverse talents rather than standardized laborers, more creative individuals rather than homogenized test takers, and more entrepreneurs rather than obedient employees."[vii] STEM education engages students in real world, meaningful experiences to develop critical thinking skills, gain job related skills, and experience the natural blend between science, math, engineering, and technology practices. Effective STEM education programs use these experiences to foster entrepreneurial and innovative thinking to solve problems for the changing world around them. Thinking towards the future is essential when applying STEM thinking and disciplines to solving problems in the ever changing landscapes of our global society.

STEM education is important for increasing the number of students leaving high school prepared to succeed in STEM fields of study and eventually STEM career pathways. High wage job opportunities in STEM fields outnumber non-STEM job opportunities currently in Oregon and are projected to increase as we understand that economic, environmental and social issues will continuously be solved through skills and knowledge in STEM disciplines.[viii] Providing diverse STEM experiences throughout the grade levels that builds artistic and creative thinking skills to solve problems and think critically gives students opportunities to determine areas of interest, strengthen foundational skills and knowledge in STEM disciplines, and have meaningful internships in the community to better understand potential career and academic pathways.

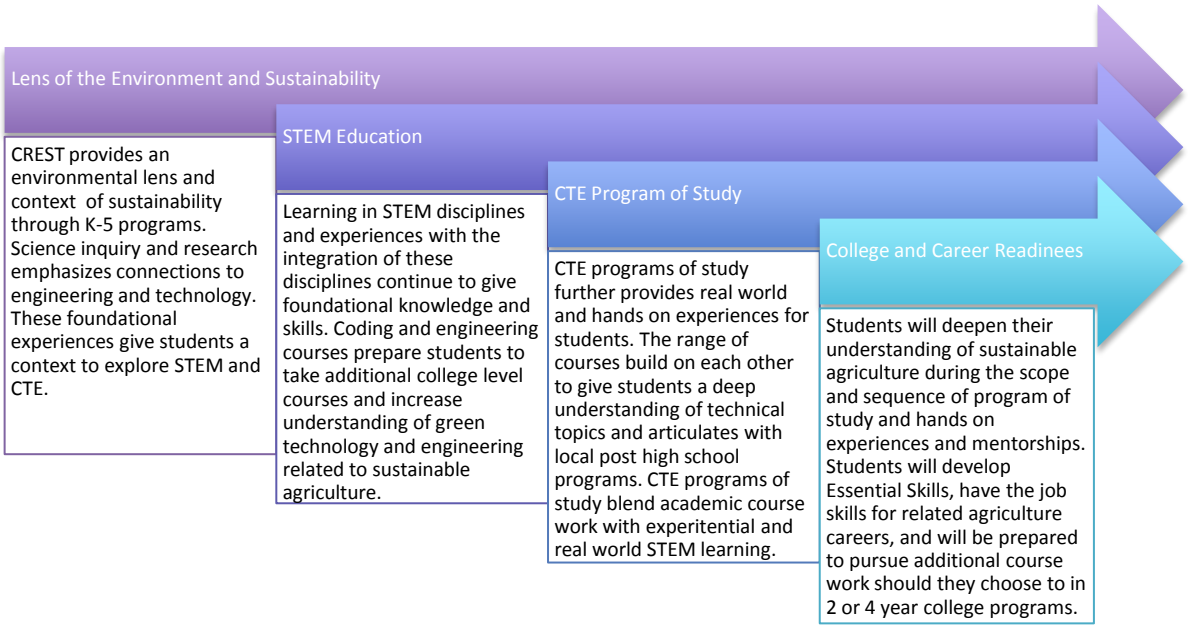
David T. Conley writes about college readiness in his research. In a report prepared for the Bill and Melinda Gates Foundation, he outlines the four facets within his comprehension definition of college readiness: key cognitive strategies, key content, academic behaviors, and contextual skills and awareness.[ix] Conley describes these facets in details in many of his publications, providing a framework for thinking about college readiness as more than course credits and standardized testing, but rather the "understanding and mastering key content knowledge… through the exercise of broader cognitive skills…"[x] While this research is central to many leadership meetings and discussions in general, it is also important as we continue to define STEM education experiences. Like all courses and experiences, we believe that formative STEM experiences should include these facets of college readiness in order to best prepare students for success in their post high school fields of study.

College and career readiness isn't reserved solely for high school programs. Using STEM education as a lens and context, middle school students tour local college campuses, talk with college students about STEM fields of study, and engage in real world, project based learning that connects students with local STEM professionals. These experiences are essential for students to be able to see themselves as successful in rigorous STEM academic programs or as they define their interest in STEM career pathways.

Career and Technical Education (CTE) Programs

The District is working to revitalize its CTE programs, especially as we support students' college and career readiness. One notion is to expand the CREST Farm to School program to include a vibrant CTE program in sustainable agriculture. This program of study would enhance existing learning and internship opportunities and

include additional academic courses related to career and technical education in agriculture. In general, CTE programs foster new and enhance existing partnerships with professionals and educational providers. A CTE program in sustainable agriculture would dovetail with existing partnerships. One possibility is that this CTE program could provide a larger context of sustainability and green engineering for eligible students to enroll in Oregon Tech's (OIT) "Introduction to Engineering" course bundle as they gain college credit. Sustainable agriculture has strong connections to engineering and having a foundational understanding of various engineering fields as a result of the OIT course bundle will be essential for any student wanting to pursue studies or a career in sustainable agriculture. Finally, through this partnership with OIT, a CTE program in sustainable agriculture would also support professional development and provide opportunities for teachers to connect with OIT professors to create additional dual credit opportunities for student in the coming years. CTE programs are important for STEM education and learning in the District.



Community Partnerships

Fostering meaningful experiences for students to engage with their community aligns with the notion that STEM education is a joint responsibility of the larger community. The District has existing partnerships that we are actively expanding and redefining as our understanding of STEM education grows. In addition to educational providers and existing industry partners, the District is working to foster new partnerships with local organizations and companies working in STEM fields to provide additional mentorship opportunities between STEM professionals and students.

South Metro-Salem STEM Partnership

The District signed a memorandum of understanding to join the South Metro-Salem (SMS) STEM partnership at the end of the 2012-2013 school year. WLWV joins thirteen other school districts in a collective effort to shape STEM education in the region with the support from industry partnerships and PK-20 education providers. The mission of the partnership is to "collective optimize PK-20 STEM education by utilizing a full spectrum of public and private resources and model instructional practices to develop a career-ready, diverse, and adaptable workforce that enhances that enhances the regional economy and community."[xi]

As of January, 2014, the industry and community partners involved in this partnership and actively offering support to school districts include: Autodesk, Eaton, First Tech Credit Union, FLIR systems, Garmin AT, Intel, Legacy Meridian Park Hospital, Mentor Graphics, PGE Foundation, Xerox, Business Education Compact, Evergreen Aviation and Space Museum, Mad Science of Portland and Vancouver, MESA (Math Engineering Science Achievement), NASA Space Grant Consortium, Oregon ASK (After School for Kids), Oregon FIRST, and Project Lead the Way. The District is working to grow these partnerships and define ways students and schools can engage with industry professionals and these companies to enhance STEM learning.

In addition to participating in the larger partnership network, District staff and administrators participate in the planning and on-going work of the Professional Learning Communities sub-committee. This group of teachers, principals, and educators work towards developing a plan for professional development for teachers within the participating Districts. This partnership provides important resources and a forum to deepen our understanding about STEM education, how to support its development and integration in schools, and ways to expand educational and industry partnerships to enhance learning opportunities for students and professional development opportunities for teachers.

Regional STEM Hub and District STEM Center

Plans to support STEM education across the state are still in development, however, we know that partnerships between industry partners, secondary educational providers, and K-12 school districts are essential. The notion of a STEM Hub contemplates how an organization like the SMS STEM partnership can have a space, the needed materials, and resources to collaborate and provide unique learning opportunities for the community in STEM learning. Similarly, we see the value in establishing a District STEM center to strengthen our existing programs and provide the space and flexibility for future endeavors. A STEM center would facilitate learning through robotics, sustainable agriculture, computer software courses, engineering design and other programs currently happening throughout the District. Cohesiveness and support around these programs will also provide important professional development opportunities for teachers looking to expand their understanding and ability to STEM education into their curriculum. As we plan for existing and future facilities and District owned properties, supporting the design of a District STEM center allows us to strengthen existing programs by meeting distinct needs for infrastructure and technologies, while also providing future opportunities to expand STEM programs through connections to Career and Technical Education (CTE) programs, as one example. While the SMS STEM partnership is applying for

funds to support a regional STEM Hub, the District is concurrently considering how a similar notion would align with our Long Range Plan, Technology Plan, and other District initiatives and vision themes.

Clackamas Community College

Clackamas Community College (CCC) provides opportunities for our students to gain advanced college credit. Students have the opportunity to enroll directly in college level courses or gain credit through dual credit courses offered at the high schools and articulate with CCC programs. As the District continues to define our STEM education program, more specific opportunities in STEM disciplines and connected to STEM career pathways and field of study will emerge within the scope of this partnership.

Clackamas Career and Technical Education (C-TEC)

The Clackamas Career and Technical Education Consortium (C-TEC) provides education, training, and employment opportunities for low-income students with barriers to employment. As stated on their website, "C-TEC is a consortium of schools and partners Clackamas County committed to creating high quality pathways from education to the workforce. The consortium prioritizes partnership, collaboration, innovation and leveraged resources to provide high quality programs and efficient use of public resources. C-TEC supports Career and Technical Education programs, Advanced College Credit, School to Careers activities, and the Workforce Investment Act Youth Program (C-TEC Youth Services)." The District's partnership with C-TEC is growing rapidly as we look to provide diverse ways for students to gain college credit, have meaningful work and career experiences, and support CTE and STED education in and out of school.

Oregon Tech (OIT)

The partnership with Oregon Tech (OIT) has possibilities around shared resources, mentorship by OIT professors for high school teachers in the District, and enrollment opportunities for eligible high school students. In thinking about supporting STEM education in the District and expanding learning opportunities for students, our partnership with OIT takes three forms: STEM High School Transition (HST) courses, dual credit offerings, and CTE course development. OIT hosted an Open House in January 2014 for District teachers, staff, administrators and community members to tour the new Wilsonville campus and learn more about OIT programs. We are working with high school counselors around scheduling and forecasting in order to help students take advantage of these enrollment opportunities in the years to come.

STEM HST Courses

We will initially focus on the "Introduction to Engineering Program" STEM HST Course bundle. This decision was made based on the void of classes currently offered at the high schools in engineering disciplines. This bundle is comprised of six courses designed to provide a solid foundation in engineering principles and an overview of the different engineering disciplines, including software and embedded engineering, electrical and electronics engineering, renewable energy engineering, and mechanical engineering. The District and OIT will work to streamline the enrollment process into three of the six courses in this bundle in the first years of this partnership. We hope to enroll a small number of eligible of students who have been identified by math teachers, high school counselors or advisors in the spring 2014 term. Courses are offered $25 per credit, in addition to course books and material costs.

Dual Credit Offerings

By identifying the prerequisites students need prior to enrolling in the Introduction to Engineering Program STEM HST course bundle, OIT staff and professors will be able to work directly with high school teachers to align curriculum for future dual credit opportunities. This will be important to ensure that course curriculum is preparing those students who elect to enroll in classes at OIT, as well as creating the opportunity for all students taking these

certain high school math classes to receive dual or accelerated credit. Determining the needed teaching credentials for these high school teachers to be qualified to teach dual credit courses will be an important piece of this work.

CTE Course Development
Within the context of revitalizing the District's Career and Technical Education (CTE) programs, OIT staff and professors have expressed interest in working with District administrators and teachers to develop relevant courses at the high school level related to the proposed program of study. A long-term goal is to provide dual credit for these courses once the CTE program is further developed.

Oregon State University (OSU) Extension

CREST has been working with OSU Extension throughout the development of the CREST Farm to School program. Weston Miller, an Urban Horticulturist with the OSU Extension Horticulture Department, has supported the program, master-planning efforts, and provided professional development opportunities for the resident farm manager. This partnership will continue as the District considers the expansion of the Farm to School program to integrate a potential Career and Technical Education (CTE) sustainable agriculture program of study.

Intel and Science Inquiry and Research

CREST has supported science inquiry and independent student research since the program officially began in 2001. A component of the science inquiry and research program has been the Intel International Science and Engineering Fair (ISEF) and the District's CREST-Jane Goodall Science Symposium. The ISEF affiliated symposium is a regional high school exposition for student projects with the following goals:

1. To provide opportunities for our talented students to compete internationally & be recognized for their achievements in science, math & related fields.
2. To create opportunities for scholarships.
3. To engage students in dialogue with practicing scientists.
4. To encourage our students to embrace math and science as career goals.
5. To enrich our business community with high achieving students focused on math & science.

Footnote References

[i] Oregon Department of Education, *Oregon STEM Education Initiative*. Web. http://www.ode.state.or.us/search/results/?id=382 Accessed: 10, January. 2014.

[ii] Oregon Department of Education, *Oregon STEM Education Initiative*. "STEM Framework Summary." Web. http://www.ode.state.or.us/search/results/?id=382 Accessed: 10, January. 2014.

[iii] Vasquez, Jo Anne, Michael Comer, and Cary Sneider. *STEM Lesson Essentials, Grade 3-8: Integrating science, Technology, Engineering, and Mathematics.* Portsmouth, NH: Heinemann, 2013. Print.

[iv] Ibid.

[v] The Digital Shift, "Meet the Makers: Can a DIY movement revolutionize how we learn?" Web. http://www.thedigitalshift.com/2013/06/k-12/meet-the-makers-can-a-diy-movement-revolutionize-how-we-learn/ Accessed: 10, January. 2014.

[vi] Maker Education Innovative, *About*. Web. http://www.makered.org/about/ Accessed: 10, January. 2014.

[vii] Zhao, Yong. *Catching up or leading the way: American education in the age of globalization*. Alexandria, VA: ASCD, 2009. Print. Page 181.

[viii] STEM Connector, *STEM State Connector Profiles*. Web. http://www.stemconnector.org/state-by-state/oregon Accessed: 10, January. 2014.

[ix] Conely, David T. *Redefining College Readiness.* Web. http://www.aypf.org/documents/RedefiningCollegeReadiness.pdf page 4. Accessed: 4, February. 2014.

[x] Ibid.

[xi] South METRO Salem STEM Partnership. Web. http://www.oit.edu/strategic-partnerships/stem-partnership Accessed: 11, January. 2014.