WASHINGTON STEM FRAMEWORK FOR ACTION AND ACCOUNTABILITY NOVEMBER 2014

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EXECUTIVE SUMMARY

Washington state is home to global science, technology, engineering, and math (STEM) industry leaders and innovators in fields such as aerospace, clean energy, high-tech, health sciences, and advanced manufacturing. The state's ability to attract, develop, and retain STEM talent is vital to the future of Washington. Yet, many young Washingtonians are not on a path to participate in and fuel the economy. It is predicted that by 2017 Washington employers will face 50,000 job vacancies due to a lack of highly skilled STEM and health care workers. While Washington has adopted Common Core State Standards (CCSS) in Math and English and Next Generation Science Standards (Next Gen) to foster the skills needed for students, the state has not made significant investments to help teachers prepare and retool their classroom practices. Additionally, students that are traditionally underrepresented in STEM jobs, including those from high-poverty families, are not catching up with their peers in math or science. Fortunately, a number of education and business leaders are working hard to address these very problems.

Washington STEM launched in 2011 with support from the business, education, and philanthropic communities to advance excellence, equity, and innovation in STEM education for all Washington students. Since their launch, Washington STEM has asked experts and practitioners across the state and nation why, despite the work by many on these issues, there is still such a gap between jobs and skilled employees. The common consensus was that there are no common goals or indicators to track results; there is a lack of agreement about what works or a mechanism to share learnings and best practices; and that resources, activities, and policies are not adequately aligned to tackle the biggest challenges, e.g. opportunity gaps and underrepresentation of minorities and women.

This led Washington STEM to lead the charge in creating a Framework for Action and Accountability (the Framework) to respond to these challenges. The Framework is a research-based tool, co-constructed with and vetted by state and national advisors, designed to spur greater coordination, smarter investments, and clear results.

FRAMEWORK COMPONENTS

Vision and Goal — Where are we going?

Our vision is that Washingtonians are prepared and inspired with the STEM skills necessary to live a life of opportunity and success in the state's thriving innovation economy and democratic society.

Our goal is for Washington to lead the nation in STEM literacy for all and to have a diverse, world-class workforce.

Priority Actions — What will we do to get there?

The Framework uses four logic models to show the activities Washington STEM and its partners will perform to reach the Framework goal. A logic model graphically depicts relationships between resources, activities, outputs, and outcomes for a program. The Framework logic models were developed through extensive research to articulate key focus areas to improve STEM education in Washington. The four logic models in the Framework are:

- Early learning through high school students;
- Early learning through high school educators;
- Post-secondary, workforce training, and employers; and
- Aligned systems.

Objectives **What will we achieve?**

Five objectives were identified to communicate priorities and desired actions and achievements within a specified time frame. These objectives will be used to guide activities (e.g., investments, programmatic initiatives, partnerships, and advocacy). The five objectives of the Framework are:

- Prepare, support, and retain excellent early learning through high school STEM teachers;
- Inspire early learning through high school Washington youth through real-world STEM learning opportunities;
- Raise public awareness and support for STEM;
- Prepare Washington's future workforce by graduating additional students with certificates and degrees in high-demand STEM fields (e.g., computer science, engineering, and health) and retraining adult workers with high-demand skills; and
- Improve equity and diversity by improving outcomes for underserved and underrepresented populations in the state (e.g., students of color, girls, and rural populations) across the previous four objectives.

Indicators **How will we measure whether we are successful in making progress and being accountable?**

A critical component of the Framework is the ability to track and measure short- and long-term progress towards achieving the outcomes in each logic model. Working in tandem with stakeholders and drawing from research, ten indicators have been drafted to correspond with the four logic models and five objectives. It was determined that the indicators should be focused, meaningful, accessible, perennial, and comparable.

Impact **What impact do we expect to make in Washington state?**

Washington STEM expects impact in two key areas: 1) sustainability of STEM in Washington state (sustainability is defined as the interaction and integration of partners, resources, and funding that allows partners to accomplish common goals); and 2) improved opportunity for Washingtonians and increased economic vitality in the state and region. Short- and long-term progress towards these two impacts will be measured with the indicators.

A TOOL TO ACCELERATE OUR IMPACT

To support implementation, Washington STEM will rely upon the Framework to prioritize its future investments and efforts. Washington STEM is working with its seven STEM Networks to ensure there is strong alignment between the Framework and each Network's business plan.

Washington STEM welcomes partners from around the state to use the Framework to maximize knowledge sharing, the spread and scale of best practices, and statewide impact. It is important to continue to engage stakeholders in all future Framework development. As progress is made, changes to the logic models will be considered and reviewed over time by statewide stakeholders and partners.

The Framework is intended to be a user-friendly tool to help focus state-level STEM education investments and efforts on proven practices and the most promising innovations. It is designed to enable the creation of a results-oriented STEM education learning community across Washington state, and, ultimately, to accelerate equity and STEM education impact at scale. Washington STEM looks forward to working with many partners to implement the Framework and to sharing its collective insights with colleagues around the state and nation.

I. INTRODUCTION

Increasing science, technology, engineering, and math (STEM) talent in Washington communities is imperative to fill jobs, grow the economy, and close opportunity gaps for the next generation – and we don't have a moment to lose. The Washington STEM Framework for Action and Accountability (the Framework) is a research-based tool developed to spur greater coordination, smarter investments, and clear results.

WASHINGTON'S STEM IMPERATIVE

Washington's communities are home to global STEM industry leaders and innovators. Washington-based companies are changing lives here at home and across the world. The state's ability to attract, develop, and retain STEM talent is vital for fostering opportunity for every Washingtonian and economic growth innovation and competitiveness. Yet, many of our young Washingtonians are not on a path to participate in and fuel our economy.

Consider the facts:

- Washington's employers are predicted to face 50,000 vacancies by 2017 due to a lack of highly skilled STEM and health care workers by 2017. The costs: $800M in lost annual tax revenue, high-paying jobs moving out of state, and reduced job creation. [i]

- Computer science – the ability to code, create algorithms, and analyze big data – is quickly becoming a high-value skillset and is a core driver of the state's skills gap. Yet, only 47 high schools in Washington offer Advanced Placement (AP) Computer Science, and out of the 711 AP Computer Science exam takers in the state in 2013, only four African-Americans and 14 Latinos passed.[ii] While the state has projected that computer science degree production needs to increase by 146% each year to meet employer demand, the state's flagship computer science undergraduate program at the University of Washington can only accommodate 30 percent of all qualified applicants due to a lack of funding and capacity. [iii]

- While Washington adopted K-12 Common Core State Standards (CCSS) in Math and English and Next Generation Science Standards (Next Gen) with the good intent to foster critical thinking and career- and college-readiness for students, the state has yet to make significant investments to help teachers retool their classroom practices. Nationally, only 23% of teachers feel very prepared to teach CCSS.[iv] Here in Washington, only 54% of teachers have received learning opportunities specific to the changes that will occur with the implementation of CCSS.[v] In science, 41 percent of elementary school teachers from across the country reported that they had not participated in any science-focused professional development in the past three years.[vi] The science professional learning needs are particularly acute now that engineering concepts and practices are included in Next Gen, the first time engineering has ever been in the state's science standards.

- Only 45% of incoming high-poverty kindergarteners in 2013 demonstrated "kindergarten-readiness" in math; yet research shows that early math skills are the greatest predictor of future academic achievement.[vii]

The good news is that Washington is home to many strong STEM education and workforce programs.

So, what's the problem? Since launching three years ago, Washington STEM has asked experts and practitioners across the state and nation that very question. Here's what we heard:

- Absence of common goals and indicators to track results.
- Lack of agreement regarding "what works" and mechanisms to share learnings and best practices, leading to a tendency to reinvent the wheel versus scale-up proof points.
- Resources, activities, and policies – local, state, federal, and private – are not focused and aligned enough to tackle really big challenges. These challenges includes persistent opportunity gaps in early learning through high school, turning computer science from an elite discipline to a natural part of the school day, and the underrepresentation of African-Americans, Latinos, Native Americans, and women in STEM majors and careers.

Washington STEM created the Washington STEM Framework for Action and Accountability (the Framework) to respond to these challenges. The Framework is a research-based tool, co-constructed with and vetted by state and national advisors and designed to spur greater coordination, smarter investments, and clear results.

WASHINGTON STEM

Washington STEM launched in 2011 to accelerate solutions to the state's STEM challenges and to forge collaboration among businesses, educators, communities, and private philanthropies. Washington STEM's vision is for all Washington high school graduates to be STEM literate, prepared to complete post-secondary degrees, and able to thrive in Washington's innovation economy and society.

Washington STEM is bringing increased focus to STEM education in the following ways:

- **STEM Convener**: Washington STEM aligns the interests of public and private partners. We create tools and resources, such as the Framework, and support a statewide community of practice for STEM.
- **STEM Innovation**: Washington STEM's STEM Innovation team incubates breakthrough ideas in STEM teaching and learning and then scales them across Washington in a cost-effective way.
- **STEM Networks**: STEM Networks are creating unified systems of STEM education in communities – fostering partnerships, eliminating the duplication of work, and increasing impact. Washington STEM's role in this process is to create a network of networks that spreads best practices among communities and drives the scaling of effective practices across the state.
- **STEM Policy**: Washington STEM offers pragmatic, nonpartisan recommendations to improve STEM teaching and learning for all students. We work with our STEM Networks, policymakers, and other education advocates to bring creative solutions that will remake our state's education system and, with it, the futures of generations of young Washingtonians.

BACKGROUND OF THE FRAMEWORK PROJECT

The Framework project began in 2013 as an initiative of Washington STEM. The purpose of the Framework is to provide a comprehensive roadmap for action in STEM education across Washington. It is designed to be a tool to identify and focus resources on high-impact innovations and solutions, drive alignment of multiple parties, and measure collective impact. The Framework was developed by Washington STEM with stakeholder and expert input and evaluation support by Battelle Memorial Institute.

The Framework presented in this report is expected to accelerate impact in the state by:

- **Aligning STEM efforts across the state of Washington with a common vision, shared goals, and clear indicators**. The Framework provides a way for the various STEM education and workforce efforts to more efficiently partner, leverage, and focus resources on key challenges and best practices and measure success. Working together, we can more rapidly and effectively act to accelerate outcomes.
- **Focusing future investments and improving return on investment**. State and private funders must make tough choices about how to focus scarce resources. The Framework will help decision-makers target investments towards promising and proven strategies, and then monitor return on investment based on measureable outcomes.
- **Providing a strategic planning and measurement tool for regional STEM Networks and other STEM efforts in the state**. Washington STEM's community based networks are using the Framework to establish regional goals; align business, education, and community partners against shared priorities; and measure results. The Framework is available to be used by other organizations across Washington.
- **Creating a common research and development agenda to test, identify, and spread promising practices**. The Framework will spur knowledge generation, learning and sharing efforts, and the development of evaluation tools and resources for researchers, policymakers, and practitioners.
- **Informing policy development and implementation**. Policymakers, advocates, researchers, and practitioners can use the Framework to develop and support policies based on evidence of effectiveness. The Framework's indicators can be used to help monitor policy implementation.
- **Providing a model for other states**. Many other states are grappling with the same set of challenges that led to the Framework's creation – absence of shared goals and measures, lack of agreement on best practices, and difficulty in focusing resources on big challenges. We offer the Framework as a tool that may be adapted and implemented by other states, particularly members of STEMx, the multi-state STEM network, in hopes that we can work smarter and faster together.

Importantly, the Framework allows Washington STEM and its partners to rally and align STEM efforts as a community of practice united by a common goal. It is an opportunity for clarification and reflection as stakeholders around the state systemically think about how various initiatives can support STEM education in the state.

KEY STEM EDUCATION DEFINITIONS USED IN THIS REPORT

Since the inception of STEM by the National Science Foundation, the term STEM education is not based on any definitive agreement on what the acronym means, beyond reference to the specific disciplines – science, technology, engineering, and mathematics.[viii] While the acronym has value for national and state policies, it has little value for designing school programs and instructional practices. Moreover, a challenge is that the acronym is not well understood among professionals in STEM fields or in the general population. While the definitional challenge is not unique to Washington STEM, it is important that efforts be focused on common definitions of STEM and STEM-related terminology if stakeholders are to align themselves and to fully understand, collaborate, and advance STEM efforts. There are a few key terms presented in the Framework and this report that are important to define. For purpose of greater clarity, we present definitions here, but it is recommended that efforts continue to refine and reflect on these definitions.

STEM* means science, technology, engineering, and mathematics.

STEM literacy* means the ability to identify, apply, and integrate concepts from science, technology, engineering, and mathematics to understand complex problems and develop innovative strategies to solve them. STEM literacy is achieved when a student is able to apply his or her understanding of how the world works within and across the four interrelated STEM disciplines to improve the social, economic, and environmental conditions of the local and global community. The component parts of STEM literacy are:

- **Scientific literacy**, which is the ability to use scientific knowledge and processes in physics, chemistry, biology, and earth and space science to understand the natural world and to participate in decisions that affect it;
- **Technological literacy**, which is the ability to use new technologies, understand how technologies are developed, and have skills to analyze how new technologies affect individuals, the nation, and the world. Technology is the innovation, change, or modification of the natural environment to satisfy perceived human needs and wants;
- **Engineering literacy**, which is the understanding of how technologies are developed through the engineering design process. Engineering design is the systematic and creative application of scientific and mathematical principles to practical ends, such as the design, manufacture, and operation of efficient and economic structures, machines, processes, and systems; and
- **Mathematical literacy**, which is the ability to analyze, reason, and communicate ideas effectively through posing, formulating, solving, and interpreting solutions to mathematical problems in a variety of situations.

STEM sustainability is defined as the interaction and integration of partners, resources, funding, and overall initiative strength that allows Washington state to accomplish its goals. This definition is derived from the STEMx Sustainability Compass which can be obtained at: http://www.stemx.us/2014/05/try-out-the-stemx-sustainability-compass/.

Quality curricula are clearly aligned with current Common Core State Standards (CCSS) and Next Generation Science Standards (NGSS) and with materials and experiences that reflect high expectations for all participants while providing opportunities for real-world applications of STEM where possible.

STEM degrees: The Department of Homeland Security maintains a list of STEM degree programs. The most updated list can be obtained at: http://www.ice.gov/sevis/stemlist.htm.

STEM careers: The Department of Labor maintains a list of STEM-related careers at: http://www.onetonline.org/find/stem?t=0.

High-demand jobs in Washington may be defined as those jobs for which there is a gap between the supply of skilled workers and expected demand. The Washington Workforce Training and Education Board maintains a list of these job fields at: http://www.wtb.wa.gov/HighDemandFields.asp.

Certificate: One example is Individualized Certificate Programs. We recommend developing a comprehensive list of possible STEM certificates that are available in Washington state and working with select stakeholders to continue refining that list.

*These items are defined by the Washington state legislature as part of E2SHB 1872.

REPORT ORGANIZATION

The remainder of this report is organized into five sections. In the next section (section II), we describe the methodology used to develop the Framework and the draft indicators. In section III we specify the Framework's vision, goals, and objectives. Section IV presents the logic models, section V presents the draft indicators, and section VI provides recommendations for next steps.

II. METHODOLOGY

PHASE I

Washington STEM launched its efforts to develop the Framework in 2013. It drew upon stakeholder input gathered from across the state during the organization's 18-month incubation phase and nearly two-years of work with funded partners, regional STEM Networks, policymakers, and state and national colleagues since its March 2011 founding. Efforts to accelerate the development of the Framework began in 2013, during which Washington STEM initiated the first phase of the Framework project.

During the first phase, Washington STEM began a review of state and national STEM education and workforce research findings, data dashboards, programs, and policies. Washington STEM also solicited feedback from national and state STEM education leaders, practitioners, and policymakers. The positive feedback regarding the value of such a framework and Washington STEM's commitment to acting upon evidence, accelerating equity and results, and spurring scalable innovations led Washington STEM to seek an evaluation contractor to support the work.

The Washington State Legislature's June 2013 passage of E2SHB 1872, comprehensive STEM education legislation that specifically calls for "a single, cohesive and comprehensive STEM Framework for Action and Accountability," added urgency and significantly increased the potential for statewide impact.

In July 2013, Washington STEM furthered the Framework development by conducting two key activities during the latter half of the year: 1) stakeholder engagement activities, which included the development of Technical Advisory Committees and a Steering Advisory Committee to review work and progress; and 2) a literature review. These activities resulted in a one-page draft Framework (see Exhibit 1) and are described in further detail here:

Stakeholder engagement. Washington STEM engaged 36 external advisors, drawing from university partners, funders, businesses, policymakers, and education leaders from Washington state and the nation. These stakeholders were grouped into two committees: a Technical Advisory Committee, consisting of stakeholders who could provide access to data and information needed to directly inform the structure and content of the Framework; and a Steering Advisory Committee that provided guidance and direction to the project by giving feedback on how to shape and move forward with the Framework. The resulting group of experts and partners provided a foundation for ensuring that the Framework was sufficiently comprehensive and that the criteria applied were rigorous and relevant to Washington STEM's vision for STEM education in the state. For a full list of project advisors, see Appendix A.

Literature review. Washington STEM, along with an evaluation contractor, examined broad areas of the research base and findings from the field to identify evidence in support of (or against) the inclusion of components in the Framework. This evidence, along with input from advisors, represents research used to identify and cite empirical evidence to support the Framework. Drafts of the literature review findings were sent to the advisory groups via email for review and feedback. Research studies identified in the literature search consisted of primary studies of specific interventions and their impacts or effectiveness, along with studies of how well interventions have been implemented, literature reviews, and meta-analyses. Criteria for inclusion of specific components of the Framework included:

- Alignment. Is the indicator, strategy, or policy aligned with the goal statement? Is the indicator, strategy, or policy appropriate for and targeted to the specified age or grade range?
- Equity. Does the indicator, strategy, or policy address the needs of students traditionally underserved in STEM education or underrepresented in STEM careers?
- Predictive nature. Is the indicator a critical checkpoint or highly predictive of downstream Framework outcomes?
- Impact. Is there empirical evidence that a strategy or policy is related to an increase in the aligned power indicator? Or is there great promise based on new research-based innovations?

INITIAL DRAFT FRAMEWORK DEVELOPED IN DECEMBER 2013 (EXHIBIT 1)

As shown, the draft Framework was divided into early learning, elementary, middle, high school and STEM post-secondary bands across the top row. The left-hand column described the result of the literature review recommending power indicators, high-impact strategies, and a policy set to accompany each band.

	Early Learning	Elementary	Middle	High	STEM Post-Secondary
Power Indicators	Kindergarten readiness	Proficient on college and career ready standards Positive attitudes toward STEM courses and experiences	Proficient on college and career ready standards Positive attitudes toward STEM courses and experiences	Graduate proficient on college and career ready standards Interest in STEM majors and careers	Meet demand for STEM jobs Earn certificates and degrees aligned to high-demand STEM jobs
High-Impact Strategies	Evidence-based professional learning for teachers and leaders Quality in- and out-of school STEM curricula High-quality preschool Student and family STEM awareness campaign	Evidence-based professional learning for teachers and leaders Quality in- and out-of school STEM curricula Student and family STEM awareness campaign Full-day kindergarten	Evidence-based professional learning for teachers and leaders Quality in- and out-of school STEM curricula Student and family STEM awareness campaign	Evidence-based professional learning for teachers and leaders Quality in- and out-of school STEM curricula Student and family STEM awareness campaign STEM industry internships Dual credit pathways	Credentialing and job skills training programs Support services that fit the needs of diverse populations Increase capacity and throughput at colleges and universities in Washington Rapid remediation Regional business post-secondary partnerships Retention and transition support
Policy Set	Recruit, prepare, and retain effective STEM teachers Include STEM in WA Kids assessment and program quality indicators Support high-quality preschool, starting with low-income students	Adopt rigorous standards and assessments (CTE and core) Recruit, prepare, and retain effective STEM teachers Incent informal learning Support full day kindergarten, starting with low-income students	Adopt rigorous standards and assessments (CTE and core) Recruit, prepare, and retain effective STEM teachers Incent informal learning	Adopt rigorous standards, assessments, and graduation requirements (CTE and core) Recruit, prepare, and retain effective STEM teachers Promote dual credit pathways and competency-based credits	Accept Smarter Balanced cut score as ready to take credit bearing course Establish production goals to meet STEM job needs & align funding Ease of credit transfer

II. METHODOLOGY

PHASE II

Phase II began in late January 2014. During Phase II, the Framework was further developed by employing logic models to articulate the theory of action and measurement to advance the Framework and provide a more in-depth articulation of the activities, outputs, outcomes and impact. In addition, a draft set of indicators was developed. The key steps and activities conducted in Phase II included:

1. Review of STEM Network business plans, additional literature review, and feedback on the draft Framework from stakeholders at the December 2013 STEM Summit.
2. Development of draft logic models and candidate indicators. The logic models are intended to depict causal pathways that link activities to outcome components. The goal of the logic models was to identify appropriate measurement given the expected activities and outcomes. This step was conducted in direct response to feedback at the 2013 December STEM Summit indicating that additional detail was needed to better articulate the expected changes and the time frame for those changes, and to develop specific measures linked to various outcomes.
3. Conduct of stakeholder review focus group meetings focusing on the draft logic models and draft indicators. For a full list of project advisors, see Appendix A.
4. Development of a set of revised and final logic models, indicators, and objectives.
5. Preparation of this report articulating the Framework activities to date.

Exhibit 2 shows how the December 2013 draft Framework was mapped into four separate logic models. This process occurred by examining the literature and working closely with stakeholders to determine appropriate groupings for the various areas of focus. As shown, components from the draft Framework around the student pipeline were combined to form Logic Model 1. Components of the draft Framework around teachers, educators, and curriculum development were combined to form Logic Model 2. Information on post-secondary education and training was combined with the workforce components and focus on adult learners. This grouping was in direct response to stakeholder feedback indicating that the workforce components were missing from the original draft Framework. These elements were combined to form Logic Model 3. Finally, an additional new piece around the systems-level coordination across all Washington state stakeholders (i.e., employing the use of a collective impact model) was developed and is represented in Logic Model 4.

Exhibit 3 shows the overview of the Framework with the four logic models linked to outcomes. The exhibit shows four interlocking logic model circles indicating the inter-connectedness of the work to be completed. These logic models link to the outcomes or goals and to the final impact statement.

DRAFT FRAMEWORK MAPPED INTO FOUR SEPARATE LOGIC MODELS (EXHIBIT 2)

VISION: Washingtonians are prepared and inspired with the science, technology, engineering and math (STEM) skills necessary to live a life of opportunity and success in the state's thriving innovation economy and democratic society.

GOAL: Our goal is for Washington to lead the nation in STEM literacy for all and to have a diverse, world-class workforce.

Group and link strategies, policies and indicators around students in early learning, elementary, middle and high school

LOGIC MODEL 1

Increase the number and diversity of STEM literate students in the education pipeline

Target: Students and Parents, Early Learning, K-12, with priority on low income individuals

Group and link strategies, policies and indicators around teachers and curriculum

LOGIC MODEL 2

Increase the capacity of teachers and schools to deliver high-quality, effective STEM education to diverse populations

Target: Teachers, Schools, School Districts, Early Learning, K-12, with priority on low income individuals

Group and link strategies, policies and indicators around post-secondary and **workforce/employment**

LOGIC MODEL 3

Increase capacity and pathways in post-secondary and adult training/learning programs to increase the number and diversity of STEM literate adults

Target: Post-secondary institutions, Employers, Workforce Training, Adult Learners, Employers

Group and link strategies, policies and indicators around **partnerships and systems-level outcomes**

LOGIC MODEL 4

Increase partnerships and capacity to monitor, fund, and advocate for STEM sustainability (systems-level outcomces)

Target: STEM partners, including STEM networks, state and local government policy makers, program planners and researchers

OVERVIEW OF FRAMEWORK WITH FOUR LOGIC MODELS LINKED TO OUTCOMES (EXHIBIT 3)

VISION: Washingtonians are prepared and inspired with the science, technology, engineering and math (STEM) skills necessary to live a life of opportunity and success in the state's thriving innovation economy and democratic society.

LOGIC MODEL 1: Early Learning through High School Students

- **Indicator 1**: STEM awareness in Washington state
- **Indicator 2**: Student interest in STEM fields
- **Indicator 3**: Student STEM achievement among early learning through high school
- **Indicator 4**: Student readiness for college-level study in STEM fields

LOGIC MODEL 2: Early Learning through High School Educators

- **Indicator 6**: STEM classes led by effective educators
- **Indicator 7**: Teachers and school leaders with STEM-related degrees

Improve equity and opportunity by improving outcomes for underrepresented groups

LOGIC MODEL 3: Post-Secondary + Employers

- **Indicator 8**: Graduates from post-secondary institutions with degrees in STEM fields
- **Indicator 9**: Alignment of STEM education programs with workforce needs of key economic sectors

LOGIC MODEL 4: Aligned Systems

- **Indicator 10**: Partnerships and funding and resource allocation for STEM education and training in Washington state

The Outcomes We Expect

- Increased number and diversity of STEM literate Washington high school students
- Increased number and diversity of Washington high school students prepared and inspired to complete STEM – focused post-secondary degrees and certificates
- Increased pool and diversity of STEM trained adults able to meet the demands of a highly skilled STEM-driven workforce

The Impact We Will Have

- Sustainability of STEM in Washington state
- Improved opportunity for Washingtonians and increased economic vitality in the state and region

III. FRAMEWORK VISION + OBJECTIVES

The Framework provides a vision and a set of measureable objectives to help guide a common agenda for STEM advancement in Washington state. In this section we describe each and their relationship to the implementation of the Framework.

- **Vision**: The Framework provides a common "vision" statement which lays out the goals for the Framework as follows: Washingtonians are prepared and inspired with the STEM skills necessary to live a life of opportunity and success in the state's thriving innovation economy and democratic society. Our goal is for Washington to lead the nation in STEM literacy for all and to have a diverse, world-class workforce.
- **Objectives**: The purpose of the objectives is to communicate priorities and desired actions and achievements within a specified time frame that can be used to guide future activities (e.g., investments, programmatic initiatives, partnerships, and advocacy). At a basic level, the objectives are also intended to help answer the question "What do I go do?"

The Washington STEM Framework was developed to target investments in five priority objective areas as follows:

1. Prepare, support, and retain excellent early learning through high school STEM teachers (linked to activities of Logic Model 2);
2. Inspire early learning through high school Washington youth through real-world STEM learning opportunities (linked to the activities of Logic Model 1);
3. Raise public awareness and support for STEM (linked to the activities of all four logic models);
4. Prepare Washington's future workforce by graduating additional students with certificates and degrees in high-demand STEM fields (e.g., computer science, engineering, health) and retraining adult workers with high-demand skills (linked to the activities of Logic Model 3); and
5. Improve equity and diversity by improving outcomes for underserved and underrepresented populations (e.g., students of color, girls, rural populations) across the previous four objectives (and linked to the activities of all four logic models).

The objectives and the specific quantifiable measures and timeframes are still being evaluated by Washington STEM. Washington STEM intends to form a work group of key stakeholders to have set numeric targets and a date for all objectives. Progress towards meeting the objectives will be measured by the indicators associated with short- and long-term outcomes within the logic models.

IV. LOGIC MODELS

INTRODUCTION

The Framework uses four primary logic models to show the actions Washington STEM and its partners will take to reach their desired goals– i.e., that all Washington high school graduates are STEM literate, prepared for and inspired to post-secondary degrees and certificates, and able to contribute to the demands of a highly-skilled and diverse STEM-driven workforce and society.

The logic model is a tool used to illustrate the presumed causal pathways that connect program inputs or resources to activities and outputs, and show the expected short-term and longer-term outcomes and impact. Logic model detail is often provided both in the form of a diagram as well as an accompanying narrative and is intended to be helpful in providing a vision to communicate the program to a broad range of stakeholders.[ix]

As well, logic models are critical in assisting in the identification and selection of various indicators to monitor both process and outcome measures and ultimately provide evidence for success and opportunities for improvement in programs and practices. In this report we articulate the logic models that constitute the Framework in both a diagram format as well as a brief narrative.

The logic models for Washington STEM were developed to describe the current configuration and infrastructure of STEM partners, current and anticipated activities, and the outcomes that are expected in the short-term (1-3 year timeframe), longer-term (4-6 year timeframe) and very long-term (7+ year timeframe).

Although the boxes of the logic models are shown in a linear fashion, the relationships among them are expected to be complex, interactive, and recursive over time. The logic models are intended to provide a common framework to describe the work of the many STEM stakeholders in the state. As such, the logic models are inclusive of a wide array of activities as they were developed by a broad range of stakeholders.

It is expected that individual stakeholder groups, such as the STEM Networks, will use the logic models to identify components that they will align their activities to and they may further work to develop additional detail around specific areas or components of the models.

Each of the logic models shown in Exhibits 4-8 detail the conceptual framework developed for the Framework project. As shown, each logic model describes the following key aspects:

- **Inputs**: the capacity to deliver services and make progress on shared goals – e.g., equipment, staff, facilities, money, and resources of partners;
- **Activities**: high-impact programs or practices and policy;
- **Outputs**: units of service delivered;
- **Outcomes**: the actual benefits and changes; and
- **Impact**: the long-term expected benefits.

Logic model note: The size of the boxes in the diagram depends on the amount of text in each box and does not denote the relative importance of a specific element.

In the sections below we describe the four primary logic models that constitute the Framework in more detail. The four logic models are focused around the following expected changes:

1. Increase the number and diversity of STEM literate students in the education pipeline (Logic Model 1);
2. Increase the diversity and capacity of teachers and schools to deliver high-quality, effective STEM education to diverse populations (Logic Model 2);
3. Increase capacity and pathways in post-secondary and adult training and learning programs to increase the number and diversity of STEM literate adults (Logic Model 3); and
4. Increase Washington STEM stakeholders' capacity to establish and accelerate shared STEM education and workforce goals (Logic Model 4).

Further, each of the four logic models contains the same set of long-term goals and impact. That is, it is expected that the activities, outputs, and short-term outcomes from all four logic models will align and lead to reaching the goals of: increased number and diversity of STEM literate Washington high school students; increased number and diversity of high school students prepared and inspired to complete STEM-focused post-secondary degrees and certificates; and, increased pool and diversity of STEM-trained adults able to meet the demands of a highly-skilled STEM-driven workforce.

LOGIC MODEL 1: EARLY LEARNING THROUGH HIGH SCHOOL STUDENTS

Logic Model 1 (Exhibit 4) focuses on delivering high-impact strategies for early learning through high school student with additional targeted activities to parents and the community in order to increase the pipeline of student prepared for future STEM degrees and jobs. This environment includes both in- and out-of-school programs as well as informal settings. Importantly, this model focuses on increasing access and opportunities for underserved and underrepresented populations in STEM.

A critical component of the Framework is the ability to track and measure short- and long-term progress towards meeting the goals. Working in tandem with stakeholders and drawing from research, ten indicators have been drafted to correspond with the four logic models and five objectives. These indicators will be discussed in greater detail in Section V.

The five Framework indicators that will be tracked to assess progress for this logic model are as follows:

- **Indicator 1** - STEM awareness in Washington state;
- **Indicator 2** - student interest in STEM fields;
- **Indicator 3** - student STEM achievement among early learning through high school;
- **Indicator 4** - student readiness for college-level study in STEM fields; and
- **Indicator 5** - 21st century skills.

Logic Model 1 was developed based on stakeholder and practitioner input as well as examination of research and findings from the field. The research focused on students in early learning through high school and identified practices and programs designed to increase student interest in future STEM degrees and jobs. These promising practices were within traditional school settings as well as in- and out-of schools settings and informal learning.

Evidence suggests that student gains in 21st century skills, such as problem solving, critical thinking, and creativity, will be needed for success, along with content knowledge in STEM. The path to a larger student pipeline ranges from making students, families, and communities aware of what STEM is and what STEM opportunities exist, as well as making those opportunities available and accessible to all. STEM as an acronym is not well understood among some communities, nor are the pathways to STEM opportunities and careers.

The research shows a need for STEM awareness campaigns, not only to articulate a definition for STEM but also to increase student interest and motivation to pursue STEM-related education and training. Unless these “upstream” educational student pipeline issues are addressed, it is unlikely that there will be a significant yield “downstream” of workers ready and able to fill STEM jobs in the future, nor progress on diversity.

The key focus of Logic Model 1 is on increasing diversity among students. The diversity target for Logic Model 1 is increased access and focus on underserved and underrepresented populations in STEM.

Exhibit 4 shows the inputs, activities, outputs, outcomes (short-term and long-term), and the expected impact for Logic Model 1. Below we describe each of these elements in more detail.

Inputs: As shown in the logic model, the inputs needed to increase the number and diversity of STEM literate students in the education pipeline require the collaboration of Washington state stakeholders and partners. Additionally, it will require significant resources (from both the government and private sector) to drive changes in STEM outcomes state-wide. These resources should focus on funding high-impact STEM school programs and practices, STEM awareness campaigns, and policy action designed to improve the STEM pipeline. It will be critical to develop a full accounting of these resources and to articulate the necessary investments as next steps in the implementation of the Framework.

Activities (High-Impact Strategies and Policy): The second column of the logic model shows the expected activities occurring which target early learning, elementary, middle, and high school students. The boxes for the four areas are shown as overlapping, indicating that these strategies and policies are interconnected. The four broad categories of high-impact strategy and policy under the activities column are as follows:

High-impact STEM school programs and practices are the promising practices and programs that will bring about desired changes in the STEM pipeline at all levels from early learning through high school graduation. It is expected that Washington STEM stakeholders will engage in high-impact STEM programs and practices. High-impact STEM programs include the promotion of early education programs and full-day kindergarten. Research indicates that students who attend any type of early education program have more success in school. Moreover, increased availability of kindergarten programs decreases the probability that a child is below grade for his or her age. It is expected that future work on the Framework will include further articulation and prioritization of STEM school programs and practices designed to increase the student pipeline.

High-impact STEM programs and practices out-of-school. It is expected that Washington STEM stakeholders will engage in the promotion of high-impact STEM programs and practices in out-of-school and informal settings as well as within traditional school settings. STEM in informal environments is a vast and expanding area that supports a broad range of learning experiences that are critical for advancing the STEM student pipeline. Informal environments for STEM learning not only include traditional science centers but also, increasingly, a much broader array of settings including after-school programs and STEM events. Evidence suggests that such experiences and programs can stimulate and enhance the STEM-specific interests of students leading to sustained interest in STEM.

STEM awareness campaigns. Best practices for student instruction in STEM capitalize on students' early interest and experiences providing them with opportunities to engage in STEM and sustain their interests.

STEM awareness campaigns seek not only to raise awareness of STEM learning opportunities, STEM fields, and career pathways among students, but many programs are also designed to reach parents, communities at large, and employers. Key messages include awareness of financial aid to support students in pursuing post-secondary education and training in STEM fields and majors. It is expected that STEM awareness campaigns will be a key activity supported in Washington state as shown in the logic model.

Policy action. Policy efforts to remove barriers and incentivize the support for and adoption of policies will be needed to bring about changes in the student STEM pipeline. Some recent efforts include the Washington State Legislature passed Senate Bill 5427 in 2011, which made WaKIDS optional for state-funded full-day kindergarten classrooms in the 2011-2012 school year and mandatory starting in the 2012-2013 school year.

In addition, policy development to incentivize informal learning is needed. In order to better support learning among underrepresented populations, informal environments for learning should be developed with the interests and concerns of the community and cultural groups in which they serve.

It is expected that as part of the efforts to make the Framework actionable, a policy agenda around increasing the student STEM pipeline will be developed.

Outputs: As the four areas of activities described above are implemented, it is expected that the following four types of outputs will follow:

- Completed efforts to increase interest in, diversity, and availability of high-quality early education and STEM-related programs from early learning through high school;
- Completed efforts to increase interest in, diversity, and availability of STEM programs out-of-school and in informal settings;
- Completed efforts to increase awareness of STEM opportunities; and
- Completed efforts to remove barriers and incentivize the support for and adoption of policies to increase the student pipeline.

It is expected that the completion of these efforts will provide feedback for identifying what works and help to improve and refine future activities listed in the activities column. This is shown at the bottom of the logic model as a feedback arrow from outputs back to activities.

Outcomes (Short-term 1-3 years): The four expected short-term outcomes from the student pipeline activities are as follows:

- Increased number and diversity of students interested in, participating in, and completing high-quality STEM-related programs early learning through high school;
- Increased number and diversity of students interested in, participating in, and completing out-of-school and informational STEM learning programs early learning through high school;
- Increased number and diversity of students, families, community members, and industry partners interested in and with knowledge of STEM fields and career opportunities; and
- Support for and adoption of policy to advance the STEM student pipeline.

Outcomes (Long-term 4-6 years): The short-term outcomes described above are expected to the lead to the following longer term outcomes:

- Increased number and diversity of STEM literate Washington high school students;
- Increased number and diversity of high school students prepared and inspired to complete STEM-focused post-secondary degrees and certificates; and
- Increased pool and diversity of STEM trained adults able to meet the demands of a highly-skilled STEM-driven workforce.

Impact (7+ years): The longer term impact that is expected is:

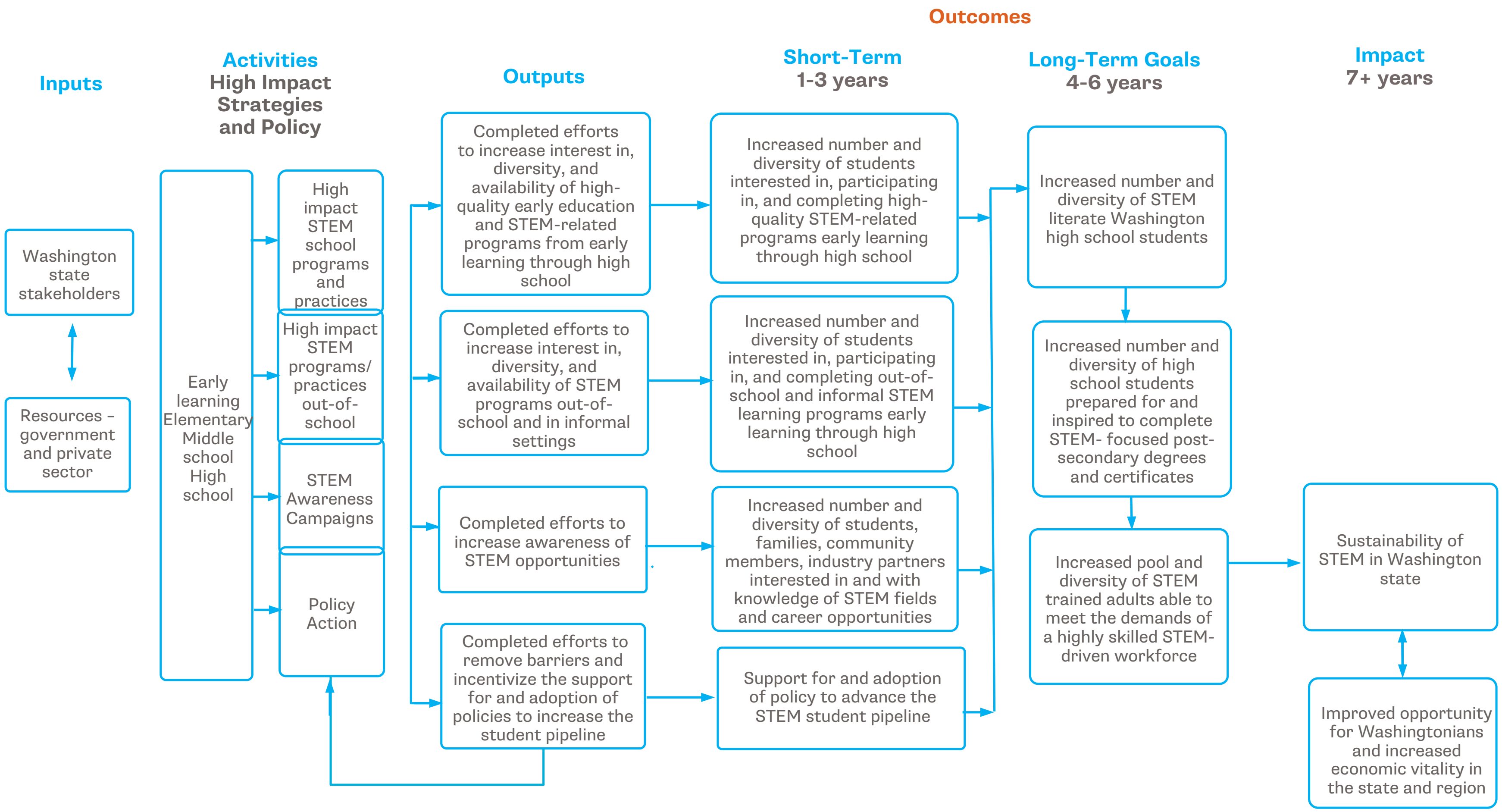
- Sustainability of STEM in Washington state; and
- Improved opportunity for Washingtonians and increased economic vitality in the state and region.

LOGIC MODEL 1: EARLY LEARNING THROUGH HIGH SCHOOL STUDENTS (EXHIBIT 4)

FOCUS: Students, parents, community, and early learning through high school; includes both in- and out-of-school programs and informal settings

DIVERSITY TARGET: Increased access and focus on underserved and underrepresented populations in STEM

INDICATORS: Indicator 1 – STEM awareness in Washington state; Indicator 2 – Student interest in STEM fields; Indicator 3 – Student STEM achievement among early learning through high school; Indicator 4 – Student readiness for college-level study in STEM fields; Indicator 5 – 21st century skills



LOGIC MODEL 2: EARLY LEARNING THROUGH HIGH SCHOOL EDUCATORS

Logic Model 2 (Exhibit 5) focuses on educators, teachers, and leaders in both in- and out-of-school and informal settings, as well as schools, school districts, and employers within the span of early learning through high school. The core of this logic model centers on increasing the diversity and effectiveness of teachers, educators, and leaders and expanding the STEM teacher pipeline.

The two Framework indicators that will be tracked to assess progress for this logic model are:

- **Indicator 6**: STEM classes led by effective educators early learning through high school; and
- **Indicator 7**: teachers and school leaders with STEM-related degrees.

Logic Model 2 was developed based on stakeholder and practitioner input as well as examination of research and findings from the field. The research in this area focuses on the need to provide evidence-based professional learning for educators, teachers, and school leaders so they are prepared to teach STEM content and skills to students.

The research also focuses on raising awareness among educators, teachers, schools, and school leaders about STEM programs, practices, and opportunities. This includes building awareness of employers and industry about potential partnerships with in- and out-of school programs, such as mentoring in schools and internship opportunities. Additionally, the research calls for the development of quality in- and out-of-school STEM curricula.

A key focus of Logic Model 2 is on increasing diversity among STEM teachers, educators, and leaders. The diversity target for Logic Model 2 is increased access and focus on underserved and underrepresented populations in STEM.

Exhibit 5 shows the inputs, activities, outputs, outcomes (short-term and long-term), and the expected impact for Logic Model 2. Below we describe each of these elements in more detail.

Inputs: As shown in the logic model, the inputs needed to increase the diversity and capacity of teachers, educators, and schools to deliver high-quality, effective STEM education to diverse populations include Washington state stakeholders and resources (from both the government and private sector) to drive changes in STEM outcomes state-wide. These resources should focus on funding professional development for educators, teachers, and school leaders, raising awareness of STEM, and the development of quality STEM programs and curricula, as well as supporting policy initiatives. A critical next step is to develop a full accounting of these resources and to articulate them as next steps in the implementation of the Framework.

Activities (High-Impact Strategies and Policy): The four broad categories of high-impact strategies and policies under the activities column are as follows:

Evidence-based professional learning for teachers and leaders. It is expected that STEM activities in Washington will include the identification and implementation of evidence-based professional learning for teachers, educators, and leaders. Evidence suggests that teacher professional development should be significant and ongoing to allow time for teachers to learn new strategies and to implement them. Teacher professional development is at the core of efforts to increase the student pipeline; teachers who are poorly prepared and lack STEM knowledge and skills translate into poor student educational outcomes and lack of student interest and engagement in STEM.

Effective professional development is focused on improving content knowledge, pedagogical skills, and assessment data to enhance instruction; policies must ensure that the core curriculum is aligned with schools and classrooms and mapped to district and state standards and assessments.[x] It is expected that as a result of these efforts to prepare effective teachers and leaders, the number and diversity of STEM educators, teachers, and leaders with content knowledge and pedagogical skills will increase. It is also expected that this will include roles for mentoring opportunities and for industry partners and professionals in the professional development process.

Awareness and development of STEM programs and practices to increase offerings of STEM education. It is expected that activities in Washington will focus on developing an awareness of STEM as well as STEM programs and practices in order to increase the offering of STEM content in a variety of settings. Evidence suggests that STEM programs should be designed such that they are unique to grade levels, disciplines, and components of the education system. In addition, STEM programs need to be aligned with national, state, and local policies. Finally, a focus is needed on increasing the diversity of STEM teachers to reflect the communities in which they work and live. To advance these efforts will likely require support from local leaders.

Development of quality in-and out-of-school STEM curricula. It is expected that activities within the state will focus on identification, development, and implementation of quality STEM curricula. This includes curricula developed for both in-school as well as out-of-schools settings. Not only should curricula be developed as part of Washington state's efforts, but efforts to increase exposure (i.e., amount of time) during the school year will also be needed to strengthen students' competencies in STEM disciplines.

In addition, efforts are expected to focus on, defining quality and implementing best practices such as incorporating more hands-on activities and encouraging more scientific discourse; enhancing core content as it connects to careers; and enhancing experiences in informal settings.[xi] Also, there is support for quality curricula being project-based and interdisciplinary, and there is an identified need for it to be co-developed with industry.

Informal and after-school experiences are often overlooked as a contributor to quality STEM programming. These programs often provide opportunities for "real-world" STEM learning opportunities and are expected to be implemented in Washington state.

Policy action. It is expected that activities within the state will be needed to remove barriers and incentivize support for the adoption of policies to recruit, prepare, and retain effective STEM teachers, educators, and leaders. Some examples of potential policy action include: improving teacher pay; providing time for teacher professional training; providing incentives for STEM teachers to teach at high-needs schools; providing incentives for industry to co-teach; and increasing training and professional development requirements.

Policy initiatives are expected to be developed to align with high-impact strategies and address system-wide changes needed to increase the diversity and capacity of teachers and schools to deliver high-quality, effective STEM education to diverse populations.

Outputs: The four expected outputs of the activities focused on high-impact strategies and policy for Logic Model 2 are:

- Completed efforts to increase the number of effective teachers and leaders;
- Completed efforts to increase awareness and availability of STEM programs and opportunities in- and out-of-school;
- Completed efforts to develop and offer quality STEM curricula and best practices both in school and in out-of-school settings; and
- Completed efforts to remove barriers and incentivize the support for and adoption of policies to recruit, prepare, and retain effective STEM teachers and leaders.

It is expected that the successful completion of these efforts will provide feedback into identifying what works and help to improve future activities conducted as part of this logic model.

Outcomes (Short-term 1-3 years): The four expected short-term outcomes are as follows:

- Increased number and diversity of effective STEM teachers and leaders with content knowledge and pedagogical skills (including mentors and industry partner professionals);
- Increased capacity to deliver high-quality STEM education and practices in- and out-of-school to diverse populations (includes mentors and industry partner professionals);
- Increased quality of STEM educational curricula and practices offered in- and out-of-school to diverse populations (includes industry partners); and
- Support for and adoption of policies to support recruitment, preparation, and retention of diverse teachers and leaders and incentives for industry mentor and partnership participation.

Outcomes (Long-term 4-6 years): The short-term outcomes described above are expected to lead to the following longer term outcomes:

- Increased number and diversity of STEM literate Washington high school students;
- Increased number and diversity of high school students prepared for and inspired to complete STEM-focused post-secondary degrees and certificates; and
- Increased pool and diversity of STEM trained adults able to meet the demands of a highly skilled STEM-driven workforce.

Impact (7+ years): The expected longer term impacts are:

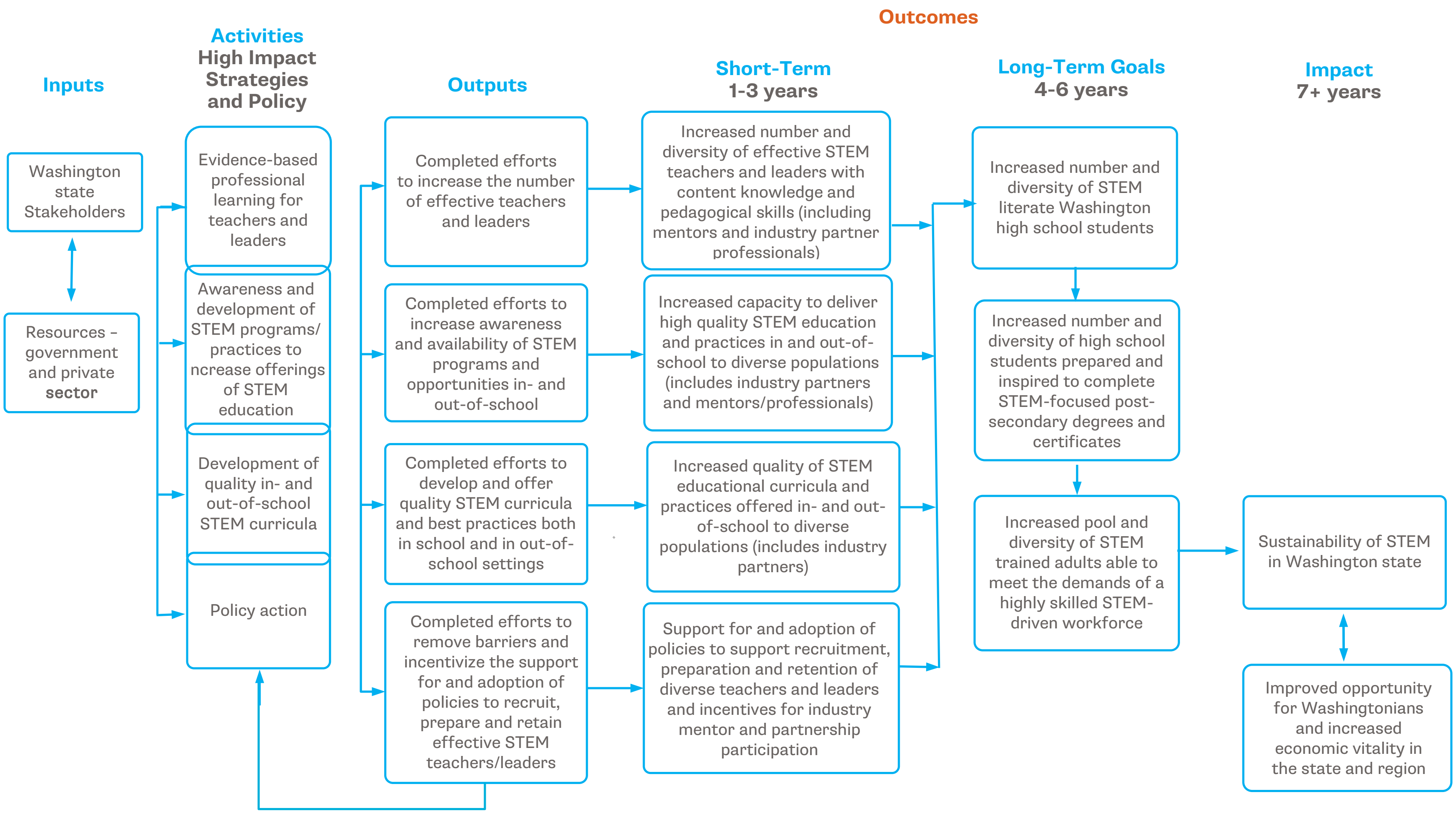
- Sustainability of STEM in Washington state; and
- Improved opportunity for Washingtonians and increased economic vitality in the state and region.

LOGIC MODEL 2: EARLY LEARNING THROUGH HIGH SCHOOL EDUCATORS (EXHIBIT 5)

FOCUS: Teachers, school leaders, schools, school districts, employers, and early learning through high school; includes both in- and out-of-school programs and informal settings

DIVERSITY TARGET: Increased access and focus on underserved and underrepresented populations in STEM

INDICATORS: Indicator 6 – STEM classes led by effective educators early learning through high school; Indicator 7 – Teachers and school leaders with STEM-related degrees



LOGIC MODEL 3: POST-SECONDARY AND EMPLOYERS

Logic Model 3 (Exhibit 6) focuses on the roles and activities of post-secondary institutions, employers, and workforce training programs in preparing adult learners. This environment includes both in-and out-of-school programs and learning opportunities. Importantly, this model focuses on increasing access for and focus on underserved and underrepresented populations in STEM.

The two Framework indicators that will be tracked to assess progress for this logic model are:

- **Indicator 8** - graduates from post-secondary institutions with degrees in STEM fields; and
- **Indicator 9** - alignment of STEM education programs with workforce needs.

Logic Model 3 was developed based on stakeholder and practitioner input as well as examination of research and findings from the field. Research indicates that there is a gap between academic degree production and employer demand in Washington, particularly in STEM fields, leading to shortages of skilled workers in the state. It also indicates that progress has been made with baccalaureate degree production in health, computer science, engineering, and other STEM fields over the last several years. However, a large gap still persists in degree production at the baccalaureate and graduate levels in the fields of computer science and engineering. In computer science, demand exceeds the current rate of degree production by 146 percent. In engineering, demand also greatly exceeds the current rate of degree production. [xii]

Recent Washington state survey results concluded that worker skill gaps continue to affect the state's employers and impact workers' ability to take advantage of high-paying employment opportunities.[xiii]

The research identifies some key strategies and policy areas necessary to address the critical need to increase capacity and pathways in post-secondary and adult training and learning programs. Specifically, the research focuses on higher education in terms of:

- increasing the capacity for STEM majors;
- improving math and science content and pedagogy in schools of education;
- improving alignment of community college and technical school degree and certificate programs with employer needs;
- increasing awareness of STEM majors among students (e.g., career exploration);
- implementation of rapid remediation programs to increase student proficiency; and
- enacting policies to remove some of the current barriers that currently exist at the post-secondary level (e.g., ease of credit transfer).

In addition, there are key strategies and policies necessary to address the needs among adult learners. There is a need for awareness of STEM jobs and careers, increased training opportunities, and fostering partnerships between workforce training programs and post-secondary institutions with employers and industry. The research recommends an increased emphasis on developing students' leadership and management skills, promotion of vital incumbent worker training through expanded avenues for continuing education, and flexible training programs leading to stackable credentials.[xiv] Without improvements in all of these areas, employers will have no recourse but to expand the recruitment of skilled workers from other states or from other countries.[xv]

The key focus of Logic Model 3 is on increasing diversity among post-secondary institutions, workforce training programs, and employers. The diversity target for Logic Model 3 is increased access and focus on underserved and underrepresented populations in STEM.

Exhibit 6 shows the relationship between expected logic model components: inputs, activities, outputs, outcomes (short-term and long-term), and the expected impact. Below we describe each of these elements in more detail.

Inputs: To increase the capacity, pathways, and diversity in post-secondary and adult training and learning programs requires collaboration of Washington state stakeholders and partners as well as resources (from both the government and private sector). Future development of the Framework will include a full articulation of the existing and required resources necessary to catalyze the changes and activities specified in the logic model.

Activities (High-Impact Strategies and Policy): The four broad categories of high-impact strategy and policy under the activities column are as follows:

Mathematics and science content and pedagogy in post-secondary schools of education. It is expected that activities by Washington STEM stakeholders will be directed towards better integration of math and science content and pedagogy in post-secondary schools of education. These efforts are critical to increasing the number of effective and diverse STEM teachers and leaders as college graduates with the necessary knowledge and skills. Reform of undergraduate teacher education programs is vital, as are continuing efforts to support future STEM teachers. It is expected that some changes may be necessary in the state's certifications and national accreditation of teachers. The logic model places special emphasis on schools of education preparing a more diverse group of future STEM teachers.

Awareness of STEM careers and majors to increase demand in post-secondary and workforce training programs (among learners). It is expected that activities by Washington STEM stakeholders will involve raising awareness of STEM careers and majors in order to increase the demand in post-secondary and workforce training programs for STEM. These efforts may target students, community, and employer engagement. These efforts are expected to lead to an increase in awareness about STEM opportunities; an increase in demand for quality STEM education, training programs, and majors; and increased capacity in workforce training programs for adult learners. It is also expected that the result will be an increased number of adult learners who are able to successfully complete STEM degrees, intern/externships, and certificates.

Remediation programs. Activities in this area include efforts to deliver rapid remediation programs in order to increase the number of students and adult learners able to successfully complete STEM degrees and certificates and to reduce the costs of remedial education in the U.S. Remedial education is needed in Washington to bring underprepared students to expected skill competency levels. It is expected that post-secondary remediation will be delivered at both two-year community colleges and four-year universities.

A review of studies on remedial education found that the programs that show the greatest benefits either mainstream developmental students into college-level courses with additional supports, provide modularized or compressed courses to allow remedial students to more quickly complete their developmental work, or offer contextualized remedial education within occupational and vocational programs.xvi

Awareness and coordination of STEM and partnerships between employers, post-secondary institutions, and workforce training programs. It is expected that Washington STEM stakeholders will raise awareness of opportunities to support education and the coordination of STEM partnerships between employers, post-secondary institutions, and workforce training programs. Efforts in this area are expected to expand STEM by fostering needed post-secondary and industry partnerships. These activities will include increased opportunities for adult learners to gain work experiences in STEM fields and careers and to receive targeted support services including those provided as part of lifelong learning.

Policy action. It is expected that policy work will be necessary to leverage the high-impact strategies pertaining to this logic model. These activities will result in completed efforts to remove barriers and incentivize the support for and adoption of policies to increase the pathways and capacity to deliver diverse experiences in STEM fields and careers. Ultimately, it is expected that these efforts will lead to the support for and adoption of policies such as ease of credit transfers and acceptance of Washington state's Smarter Balanced Assessment cut score as ready to take credit bearing courses. In addition, focus will be on policies to incentivize increases in capacity and to foster and support diversity within post-secondary and adult learning programs.

Outputs: The four expected outputs of the activities conducted and described above include the following:

- Completed efforts to increase math and science content and pedagogy in post-secondary schools of education;
- Completed efforts to increase awareness and demand for and quality of STEM program and majors and capacity in workforce training programs to provide services;
- Completed efforts to deliver remediation;
- Completed efforts to foster and sustain post-secondary and industry partnerships; and
- Completed efforts to remove barriers and incentivize the support for and adoption of policies to increase pathways and capacity to deliver diverse experiences in STEM fields and careers.

It is expected that the successful completion of these efforts will provide feedback into identifying what works back to the activities, which will allow the activities to become more focused on effective practice in the future.

Outcomes (Short-term 1-3 years):

- Increased number of effective and diverse STEM teachers and leaders as college graduates;
- Increased number of adult learners who are able to successfully complete intern/externships, degrees, and certificates;
- Increased and rapid remediation to adult learners who are able to successfully complete degrees and certificates;
- Increased opportunities for adult learners to gain work experience in STEM fields and careers and receive targeted support services (e.g., lifelong learning); and
- Support for and adoption of policies to promote opportunities and increase capacity and pathways to STEM (e.g., capacity, ease of credit transfers, and acceptance of Smarter Balance cut score as ready to take credit bearing course).

Outcomes (Long-term 4-6 years):

- Increased number and diversity of STEM literate Washington high school students;
- Increased number and diversity of high school students prepared for and inspired to complete STEM-focused post-secondary degrees and certificates; and
- Increased pool and diversity of STEM trained adults able to meet the demands of a highly skilled STEM-driven workforce.

Impact (7+ years):

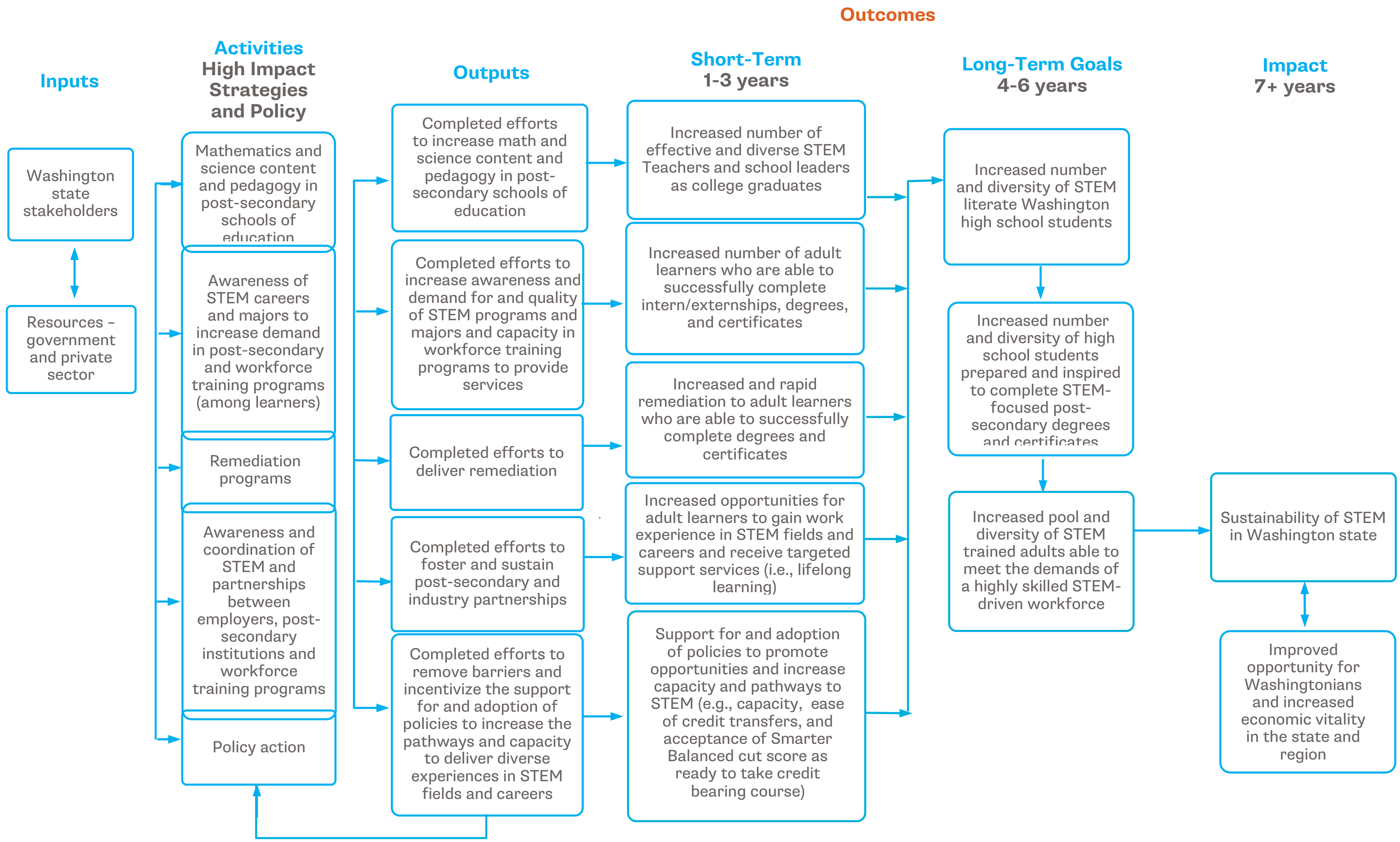
- Sustainability of STEM in Washington state; and
- Improved opportunity for Washingtonians and increased economic vitality in the state and region.

LOGIC MODEL 3: POST-SECONDARY AND EMPLOYERS (EXHIBIT 6)

FOCUS: Post-secondary institutions, employers, workforce training, adult learners, employers; includes both in- and out-of-school programs and informal settings

DIVERSITY TARGET: Increased access and focus on underserved and underrepresented populations in STEM

INDICATORS: Indicator 8 – Graduates from post-secondary institutions with degrees in STEM fields; Indicator 9 – Alignment of STEM education programs with workforce needs



LOGIC MODEL 4: ALIGNED SYSTEMS

Logic Model 4 (Exhibit 7) focuses on increasing the capacity of Washington STEM stakeholders and partners to establish and accelerate shared STEM education and workforce goals. This is a systems-level logic model that focuses on promoting a collective impact model by Washington STEM and its STEM Network partners; the governor; the executive branch; the legislature; OSPI; higher education; economic development and workforce agencies; key program providers; employers; and policy, advocacy, and research groups.

The Framework indicator that will be tracked to assess progress for this logic model is Indicator 10 - partnerships and funding and resource allocation for STEM education and training in Washington state.

Logic Model 4 was developed based on stakeholder and practitioner input as well as examination of research and findings from the field. The research suggests that large scale social change, such as education reform and specifically STEM education, benefits from a framework that utilizes a collective impact model. In a collective impact model, change comes about as a result of broad cross-sector coordination. Specifically, it is anticipated that the changes needed to drive better outcomes in STEM will come about if nonprofits, governments, businesses, and the public are brought together around a common agenda.xvii Research also shows that successful collective impact initiatives typically have five conditions that together produce true alignment and lead to powerful results:

- A common agenda;
- Shared measurement systems;
- Mutually reinforcing activities;
- Continuous communication; and
- Backbone support organizations.

For the Framework, these key activities or conditions will be brought about by a focus around the work of the Governor's STEM Education Innovation Alliance1, the governor, legislature, state agencies, Washington STEM, the STEM Networks, and private and public partners. These entities are expected to work together to advance STEM education and the work of the other three logic models.

The key focus of Logic Model 4 is on diversity, as it is for the previous three logic models. The diversity target for this logic model is coordinated work around system-wide efforts to increase access for and focus on underserved and underrepresented populations in STEM.

Exhibit 7 shows the inputs, activities, outputs, outcomes (short-term and long-term), and the expected impact for Logic Model 4. Below we describe each of these elements in more detail.

Inputs: As shown in the logic model, the inputs needed to increase Washington STEM stakeholders' capacity to establish and accelerate shared STEM education and workforce goals include Washington STEM's stakeholders, its STEM Network partners, and resources from both the government and private sectors. A challenge for this work is that funding collective impact initiatives costs money, but it is a highly-leveraged investment. For example, a backbone organization with a modest annual budget can support a collective impact initiative of several hundred organizations, magnifying the impact of existing funding. As described in the previous logic model descriptions, a critical next step will be to identify the current and needed resources and the roles and responsibilities of the various stakeholders in implementing a collective impact model with Washington STEM as the backbone organization.

[1] Established by E2SHB 1872 in 2013 and formally launched in 2014, the Governor's STEM Education Innovation Alliance (STEM Alliance) advises the governor and provides vision and guidance in support of STEM education initiatives from early learning through post-secondary education. The STEM Alliance is made up of representatives of businesses, educational institutions, and organizations with expertise in STEM education. The governor's office, OSPI, and other state education agencies are also represented.

Activities (High-Impact Strategies and Policy): The activities of Logic Model 4 fall within the scope of four primary entities:

Governor's STEM Education Innovation Alliance. It is expected that the Governor's STEM Education Innovation Alliance will set, monitor, and support statewide STEM talent production goals.

Governor, legislature, and state agencies. It is expected that the governor, the legislature, and state agencies will prioritize STEM in policy, budget, and planning efforts.

Washington STEM. It is expected that Washington STEM will lead activities to advance common goals for STEM education with its STEM Networks and public and private partners (additional detail on Washington STEM serving as a backbone organization is provided in the next section).

STEM Networks, public and private partners. It is expected that Washington STEM's STEM Networks, public partners, and private partners will inform and commit to common goals and participate in aligned activities to increase coordination and impact.

Outputs: The four expected outputs of the program include the following:

- Completed partnerships and Memorandums of Understanding (MOUs) with partners reflect common agenda and goals;
- Completed efforts to coordinate goal setting, best practice identification and sharing, data analysis, and advocacy;
- Completed efforts to set talent production goals by the Governor's STEM Education Innovation Alliance;
- Completed efforts to prioritize STEM in policy, budget, and planning efforts; and
- Completed efforts by Washington STEM to coordinate statewide STEM activities.

It is expected that the successful completion of these efforts will provide feedback into identifying what works back to the activities, which will allow the activities to become more focused on effective practice in the future.

Outcomes (Short-term 1-3 years):

- Increased resource allocation to effective STEM practices;
- Adoption of and effective implementation of evidence-based STEM policies and practices;
- Increased public demand and political will for effective STEM policies and practices;
- Increased transparency regarding STEM program outcomes and ability to measure return on investment (ROI); and
- Alignment of regional STEM support systems to improve student outcomes.

Outcomes (Long-term 4-6 years):

- Increased number and diversity of STEM literate Washington high school students;
- Increased number and diversity of high school students prepared and inspired to complete STEM-focused post-secondary degrees and certificates; and
- Increased pool and diversity of STEM trained adults able to meet the demands of a highly-skilled STEM-driven workforce.

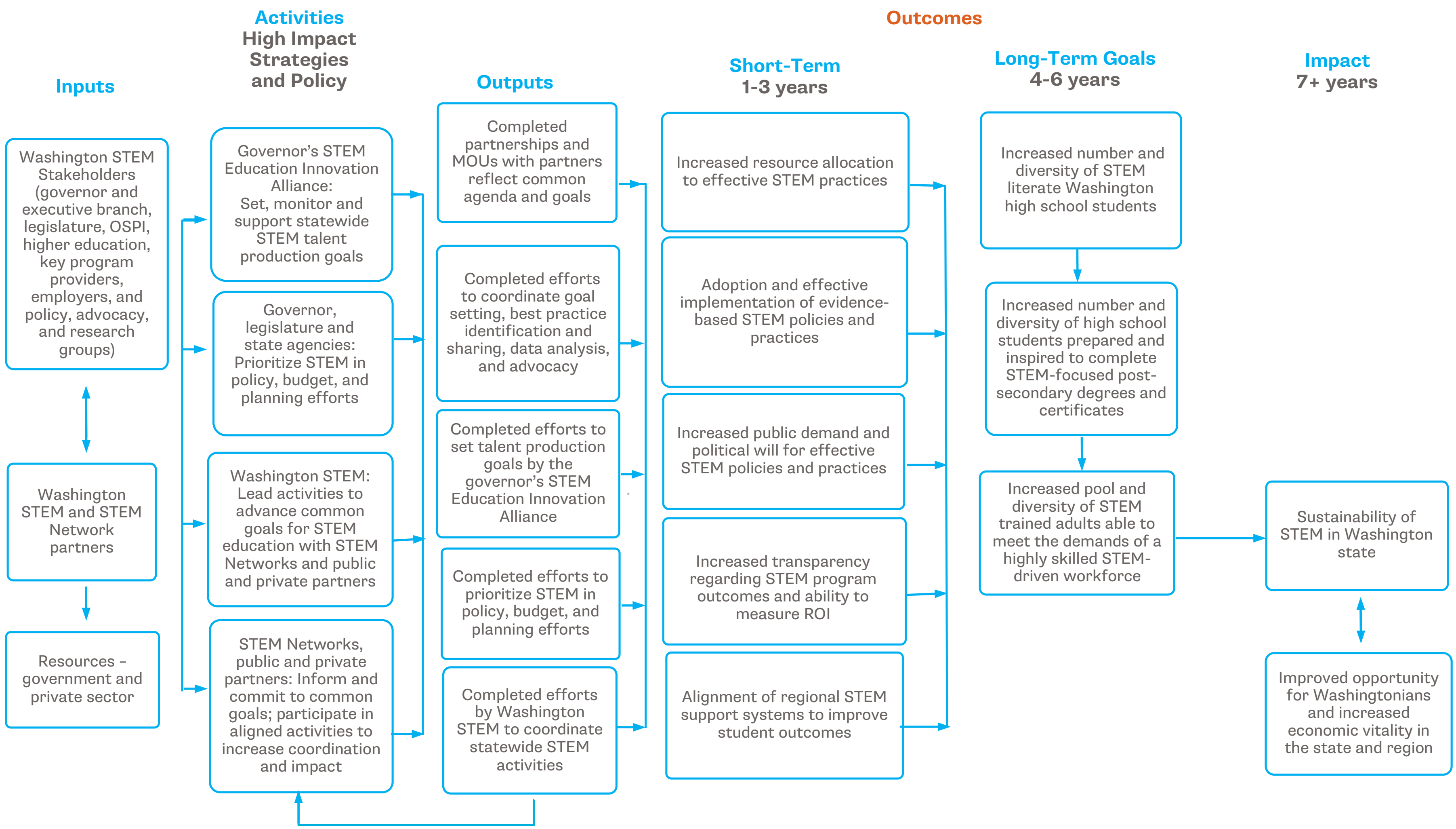
Impact (7+ years):

- Sustainability of STEM in Washington state; and
- Improved opportunity for Washingtonians and increased economic vitality in the state and region.

LOGIC MODEL 4: ALIGNED SYSTEMS (EXHIBIT 7)

FOCUS: Washington STEM, STEM Network Partners, governor and executive branch, legislature, OSPI, higher education, economic development and workforce agencies, key program providers, employers, and policy, advocacy, and research groups

INDICATORS: Indicator 10 – Partnerships and funding and resource allocation for STEM education and training in Washington state



LOGIC MODEL 4 DETAIL: WASHINGTON STEM AS A BACKBONE ORGANIZATION

The previous section on Logic Model 4 discussed the collective impact model being integrated into the Framework and the benefits of cross-sector coordination. As part of this model, it is expected that Washington STEM and its STEM Networks will serve as a joint backbone organization providing leadership to coordinate its initiatives statewide. Logic Model 4 detail (Exhibit 8) defines their roles in the collective impact model. This model is useful for identifying ways to facilitate and lead a common agenda for STEM education statewide. Effective backbone support is a critical condition for collective impact as a lack of a strong backbone is the primary reason that collective impact initiatives fail.[xviii] According to a Stanford Social Innovation review article:

> The work of a backbone organization is complex. The roles played in accelerating change can be challenging to articulate as, by design, their work is largely behind the scenes. Therefore, The Greater Cincinnati Foundation's (GCF) new approach to community leadership means that evaluating and communicating the value of backbone organizations has become all the more important. In addition, defining and communicating what "effectiveness" really means is another driver of the Foundation's work.[xix]

It is expected that over time, with Washington STEM and its STEM Networks serving as a backbone organization, coordinated activities will lead to changes among partners, funders, policymakers, and community members. These activities will lead to more effective systems and improved community outcomes. While there are challenges to effective implementation of a backbone organization, Washington STEM and its STEM Networks understand these challenges and are committed to doing the work necessary to effect change across the state.

Exhibit 8 provides additional detail regarding Washington STEM and its STEM Networks' role as a backbone organization in STEM.

Inputs: As shown in this logic model, the inputs require the collaboration of Washington STEM and its STEM Networks, as well as resources to drive changes in STEM activities state-wide. These resources are expected to be those at the federal, state, and local government levels.

Activities (High-Impact Strategies and Policy): The primary activities that will be conducted by Washington STEM and its STEM Networks are shown under the activities column and are:

- Guide vision and strategy;
- Support aligned activities;
- Establish learning, evaluation, and a shared measurement system (SMS);
- Build public will;
- Advance policy;
- Mobilize funding; and
- Lead communication and aligned activities with external partners.

Outputs: The seven expected outputs include the following:

- The Framework and the STEM Network MOUs reflect a common agenda and goals;
- Washington STEM supports communication and coordination across its STEM Networks;
- Washington STEM supports evaluation and a shared measurement system (SMS) to track progress and support learning and decision-making with its STEM Networks;
- Washington STEM creates stories, polls, and other tools to spur public awareness and action;
- Washington STEM and its STEM Networks create and advocate for a shared policy agenda;
- Washington STEM supports efforts to realign and attract new resources to develop a common agenda and goals; and
- Washington STEM and its STEM Networks partner with key system actors to advance common goals.

Outcomes (Short-term 1-3 years):

- Creation and alignment of statewide STEM Networks to improve student outcomes;
- Identification and transfer of best practices across the state;
- Increased public demand and political will for effective STEM policies and practices;
- Increased transparency regarding STEM outcomes and ability to measure return on investment (ROI);
- Adoption of and effective implementation of evidence-based STEM policies; and
- Alignment of existing resources to support a common agenda and goals.

Outcomes (Long-term 4-6 years):

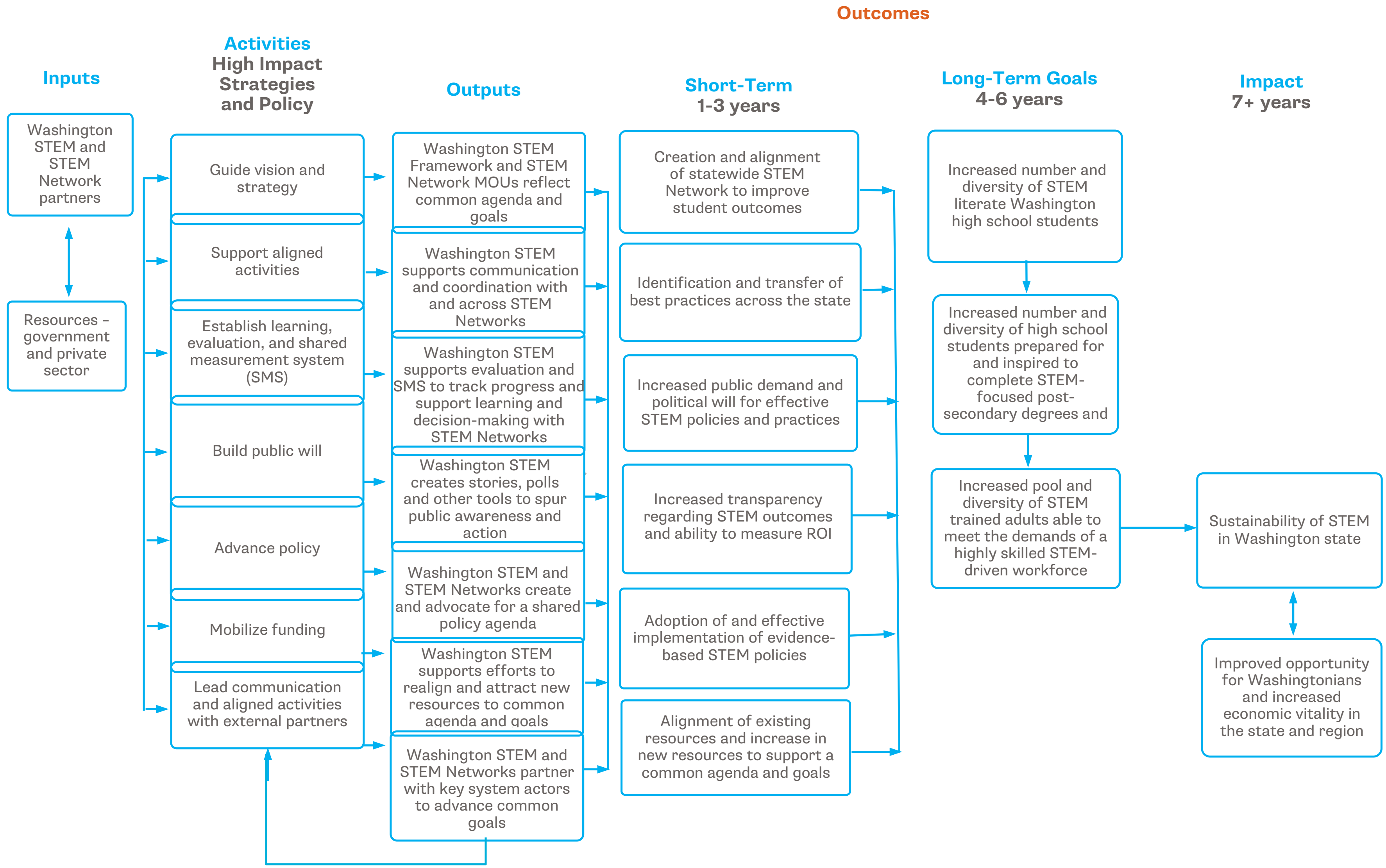
- Increased number and diversity of STEM literate Washington high school students;
- Increased number and diversity of high school students prepared and inspired to complete STEM-focused post-secondary degrees and certificates; and
- Increased pool and diversity of STEM trained adults able to meet the demands of a highly-skilled STEM-driven workforce.

Impact (7+ years):

- Sustainability of STEM in Washington state; and
- Improved opportunity for Washingtonians and increased economic vitality in the state and region.

LOGIC MODEL 4 DETAIL: WASHINGTON STEM AS A BACKBONE ORGANIZATION (EXHIBIT 8)

FOCUS: Washington STEM and STEM Network Partners' Role



V. DRAFT INDICATORS

PURPOSE

A critical component of the Framework is the ability to track and measure short- and long-term progress towards meeting the goals. Working in tandem with stakeholders and drawing from research, ten indicators have been drafted to correspond with the four logic models and five objectives. This section describes the preliminary work done to develop the draft indicators. The following five criteria were used to select the indicators:

- **Be Focused**: Each indicator should speak directly to Washington's educational and workforce status in STEM-related areas. In addition, data should be disaggregated to the degree possible to provide information on underserved and underrepresented populations in STEM.
- **Be Meaningful**: Data should be useful to a wide variety of audiences and purposes.
- Be Accessible: Data should be available at little or no cost through currently existing secondary sources. Note: Measures may be expanded to include those that require new data collection efforts.
- **Be Perennial**: Data should be consistently available on an annual (or other regular) basis so they may be comparable over time.
- **Be Comparable**: Reporting of data should be comparable at various levels (U.S., state, Networks) to the extent desirable and feasible.

For purposes of the indicators described in this section, Washington STEM uses a broad definition of STEM that incorporates all of the following subject and/or employment areas:

- Agriculture, conservation, and natural resources;
- Architecture;
- Biological and biomedical sciences;
- Computer and information sciences;
- Engineering and engineering technologies/technicians;
- Health professions and clinical sciences;
- Mathematics and statistics;
- Mechanic and repair technologies/technicians;
- Military technologies/technicians;
- Physical sciences;
- Precision production; and
- Science technologies/technicians.

As a result, data from Washington state may not be comparable to data from other sources that use a different definition of STEM.

The Framework indicators also draw upon the successful work of the Massachusetts Statewide STEM Indicators Project (MASSIP).xx

TEN DRAFT INDICATORS

To date, Washington STEM has developed ten draft Framework indicators. They are as follows:

- **Indicator 1**: STEM awareness in Washington state.
- **Indicator 2**: Student interest in STEM fields.
- **Indicator 3**: Student STEM achievement among early learning through high school.
- **Indicator 4**: Student readiness for college-level study in STEM fields.
- **Indicator 5**: 21st century skills.
- **Indicator 6**: STEM classes led by effective educators in early learning through high school.
- **Indicator 7**: Teachers and school leaders with STEM-related degrees.
- **Indicator 8**: Graduates from post-secondary institutions with degrees in STEM fields.
- **Indicator 9**: Alignment of STEM education programs with workforce needs of key economic sectors.
- **Indicator 10**: Partnerships and funding and resource allocation for STEM education and training in Washington state.

INDICATORS LINKED TO LOGIC MODELS

Each of the indicators is linked to a logic model for purposes of measurement and are detailed below.

Indicator 1 STEM Awareness in Washington State

Measures developed under this indicator will focus on whether there has been an increase in awareness of STEM in the state of Washington. These data are likely to be derived from a survey by Washington STEM of state voters.

This indicator is linked to Logic Model 1.

Indicator 2 Student Interest in STEM Fields

Measures developed under this indicator will focus on whether there is an increased interest in STEM college majors among college-bound Washington public school graduates. In addition, the measures will seek to demonstrate:

- Increased interest among the underrepresented gender in fields with a gender-based gap in interest;
- Increased interest among underrepresented races and ethnicities in fields with a race or ethnicity-based gap in interest;
- Increased interest in fields where there are anticipated gaps in future employment (from industry group and/or from retirement of current employees); and
- Increased interest in STEM fields at early ages (including preschool and elementary school) to assist in increasing student motivation to attain higher levels of STEM academic achievement and performance.

This indicator is linked to Logic Model 1.

Indicator 3 STEM Achievement among early learning through high school Students

Measures developed under this indicator will focus on whether there is an increase in the percentage of all students scoring proficient or advanced on statewide mathematics assessments. In addition, the measures will seek to demonstrate:

- Increased percentage of all 5th and 8th grade students scoring proficient or advanced on statewide mathematics assessments;
- Increased percentage of all high school students scoring proficient or advanced on statewide mathematics assessments; and
- A reduction in the achievement gaps of 5th grade, 8th grade, and high school students on the statewide mathematics assessments.

This indicator is linked to Logic Model 1.

Indicator 4 Student Readiness for College-Level Study in STEM Fields

Measures developed under this indicator will focus on whether there is an increase in the percentage of Washington public high school students who report taking at least four years of math and three years of lab-based science, consistent with Common Core State Standards and Next Generation Science Standards, as well as an increase in the percentage of Washington public high school students who report taking advanced mathematics (pre-calculus and above). In addition, the measures will seek to demonstrate:

- Increased STEM course-taking among the underrepresented gender in courses with a gender-based gap in participation; and
- Increased STEM course-taking among underrepresented races and ethnicities in courses with a race or ethnicity-based gap in participation.

This indicator is linked to Logic Model 1.

Indicator 5 21st Century Skills

Measures developed under this indicator will focus on whether there is an increase in the percentage of students with problem solving, critical thinking, and creativity skills. Data will be supported by measures from PISA (The Programme for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study).

This indicator is linked to Logic Model 1.

Indicator 6 STEM Classes Led by Effective Educators from Early Learning Through High School

Measures developed under this indicator will focus on whether there is an increase in the percentage of Washington public school classes taught by highly qualified teachers.

This indicator is linked to Logic Model 2.

Indicator 7 Teachers (Early Learning Through High School) with STEM-Related Degrees

Measures developed under this indicator will focus on whether there is an increase in the percentage of teachers (early learning through high school) with an undergraduate major in a STEM-related field. In addition, the measures will seek to demonstrate:

- Increased number of teachers with STEM undergraduate majors (e.g. math and science) among underrepresented gender in majors with a gender-based gap in degrees; and
- Increased number of teachers with STEM undergraduate majors (e.g. math and science) among underrepresented race and ethnicities in majors with a race or ethnicity-based gap in degrees.

This indicator is linked to Logic Model 2.

Indicator 8 Graduates from a Post-Secondary Institution with a Degree in STEM Fields

Measures developed under this indicator will focus on whether there is an increase in the number of students who complete STEM post-secondary degrees at Washington public and private institutions. In addition, the measures will seek to demonstrate:

- Increased number of bachelor's degrees granted in all STEM majors to all students;
- Increased number of bachelor's degrees granted in all STEM majors to the underrepresented gender in majors with a gender-based gap in degrees; and
- Increased number of bachelor's degrees granted in all STEM majors to the underrepresented race and ethnicity in majors with a race or ethnicity-based gap in degrees.

This indicator is linked to Logic Model 3.

Indicator 9 Alignment of STEM Education Programs with the Workforce Needs of Key Economic Sectors

Measures developed under this indicator will focus on demonstrating:

- Improved competence (knowledge, skills, and attitudes) of current and prospective workers for in-demand career tracks across relevant job levels;
- Increased availability and diversity of STEM-competent workers to support the replacement (due to retirement) and growth needs of employers;
- Increased total employment of the STEM workforce, regionally and statewide;
- Increased number of STEM education programs that address in-demand career tracks and jobs for key economic sectors;
- Improved response of vocational schools and colleges and universities to adjust capacity of STEM programs consistent with projections for a more diverse pipeline of new and replacement STEM workers;
- Increased number of experiential learning opportunities offered in each key economic sector, statewide and regionally, as a percentage of enrolled students;
- Quantifying the number and percentage increase of Washington STEM talent hires, including underrepresented group hires;
- Decreased persistent and above-norm vacancy rates for in-demand STEM defined job categories; and
- Measurement and reporting (growth or decline) of STEM job postings by economic sector and career tracks (e.g. technical, managerial, scientist, engineer) as a percentage of employment in these sectors and tracks.

This indicator is linked to Logic Model 3.

Indicator 10 Partnerships and Funding and Resource Allocation for STEM Education and Training in Washington State

Measures developed under this indicator will focus on demonstrating the effectiveness of the collective impact model. It will also focus on whether there is evidence of increased funding and resources for STEM education and training in Washington state as a result of the activities of the Framework. Community-level measures may include information on the number of new partnerships and collaborations, regardless of whether or not there is aligned data collection, policies, practices, and funding. Organizational-level measures may include information of whether evidence exists for: new or revised programs or practices; new or revised policies; changes in resource use; and changes in data collection and use.

This indicator is linked to Logic Model 4.

VI. CONCLUSION AND RECOMMENDED NEXT STEPS

The Framework contained in this report should be considered a "living document" – that is, it is expected to change and improve over time as stakeholders conduct the important work articulated within the Framework. It is critical now more than ever to take action. Washington has the opportunity to become a world-class STEM education hub. Its ability to attract, develop, and retain STEM talent in the future, which will be the key to economic vitally by driving innovation, improving productivity, and providing opportunities for all Washington citizens, rests on the implementation of a statewide Framework for action and accountability.

Washington STEM will rely upon the Framework to prioritize its future investments and efforts. It will use its role as the statewide STEM education convener to lead efforts across the state. It will also support its growing system of regional STEM Networks to use the Framework as a strategic planning and measurement tool. Washington STEM welcomes partners from around the state to use the Framework in order to maximize knowledge sharing, the spread and scale of best practices, and statewide impact. It is important to continue to engage stakeholders in all future Framework development. As progress is made, changes to the logic models will be considered and reviewed over time by state-wide stakeholders and partners.

An important initial task of the Governor's STEM Education Innovation Alliance (STEM Alliance), as called for in E2SHB 1872, will be to adopt a Framework for action and accountability. Washington STEM shared its Framework with the STEM Alliance to consider for adoption. Once they adopt a framework, a STEM Benchmark Report Card (Report Card) will be developed based on the proposed Framework measures. The purpose of the Report Card will be to monitor progress in aligning strategic plans, resources, and activities in order to prepare students for STEM-related jobs and careers, with the long-term goal of improving educational, workforce, and economic outcomes.

It is important to establish measurable goals for the Framework objectives by providing specific time frames and quantifying the magnitude of the changes expected. These objective include:

- Inspire early learning through high school Washington youth through real-world STEM learning opportunities (linked to the activities of Logic Model 1);
- Prepare, support, and retain excellent early learning through high school STEM teachers (linked to activities of Logic Model 2);
- Prepare Washington's future workforce by graduating additional students with certificates and degrees in high-demand STEM fields (e.g., computer science, engineering, health) and retraining adult workers with high-demand skills (linked to the activities of Logic Model 3);
- Raise public awareness and support for STEM (linked to the activities of all four logic models); and
- Improve equity and diversity by improving outcomes for underrepresented and underserved populations (e.g., students of color, girls, rural populations) across the previous four objectives (and linked to the activities of all four logic models).

In addition, further development of the ten indicators is necessary to begin the preparation of statewide report cards. Moreover, Washington STEM will work with its STEM Networks to ensure alignment of activities and indicators contained in the Framework. In order for the Framework to continue to have relevance and to be used, it will be important to take advantage of on-going opportunities to engage stakeholders, to share best practices learned, and to explore vehicles for broader communication of the Framework in the future.

The Washington STEM Framework for Action and Accountability is intended to be a "user friendly" organizing tool to help focus state-level STEM education investments and efforts on proven practices and the most promising innovations. The Framework is designed both to accelerate equity and results at scale and enable the creation of a results-oriented and purposeful STEM education learning community across Washington.

REFERENCES

LOGIC MODEL 1 REFERENCES

Barett, W. S., Hustedt, J. T., Robin, K. B., & Schulman, K. L. (2004). *The state of preschool: 2004 state preschool yearbook*. New Brunswick, NJ: NIEER.

Beggs, J. M., Bantham, J. H., & Taylor, S. (2008). Distinguishing the factors influencing college students' choice of a major. *College Student Journal, 42,* 381-394.

Bybee, R.W. (2013). *The Case for STEM Education: Challenges and Opportunities. National Science Teachers Association.* NSTA Press: Arlington, Virginia.

Common Core State Standards Initiative. (2010). *Common core state standards for mathematics*. Retrieved from: http://www.corestandards.org/Math/

Duhley, E. (2011). Who Benefits from Kindergarten? Evidence from the introduction of state subsidization. *Educational Evaluation and Policy Analysis, 33*(1), 3-22.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., Pagani, L. S., & Feinstein, L. (2007). Meta-analysis of research on school readiness and later achievement. *Developmental Psychology*, *43*(6), 1428-1446. http://dx.doi.org/10.1037/0012-1649.43.6.1428.

Gormley, W. T., Gayer, T., Phillips, D., & Dawson, B. (2005). The effects of the universal pre-k on cognitive development. *Developmental Psychology, 41*(6), 872.

Hall, C., Dickerson, J., Batts, D., Kauffmann, P., & Bosse, M. (2011). Are we missing opportunities to encourage interest in STEM fields? *Journal of Technology Education 25*(1), 32-46.

Kuechler, W. L., McLeod, A., & Simkin, M. G. (2009). Why don't more students major in IS? *Decision Sciences Journal of Innovative Education, 7,* 463-488.

Magnuson, K. A., Meyers, M., Ruhm, C., & Waldfogel, J. (2004). Inequality in preschool education and school readiness. *American Educational Research Journal*, *41,* 115–157.

Magnuson, K. A., Ruhm, C., & Waldfogel, J. (2007). Does prekindergarten improve school preparation and performance? *Economics of Education Review*, *26*(1), 33-51.

Malgwi, C. A., Howe, M. A., & Burnaby, P. A. (2005). Influences on students' choice of college major. *Journal of Education for Business*, 80(5), 275-282.

My College Options and STEMconnector. (2012). Where are the STEM Students? What are their Career Interests? Where are the STEM Jobs? Retrieved from: http://www.stemconnector.org/sites/default/files/store/STEM-Students-STEM-Jobs-Executive-Summary.pdf

Nance, R. (2009). The importance of early childhood education. *Quest Paper*, 2-19. Retrieved from: http://www.fwquestclub.com/welcome_files/papers/childhood_education.pdf

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel*. Washington, DC: U.S. Department of Education. Retrieved from: http://www2.ed.gov/about/bdscomm/list/mathpanel/report/finalreport.pdf

National Research Council. (2005). *How students learn: Mathematics in the classroom*. Washington, DC: The National Academies Press.

National Research Council. (2007). *Taking science to school: Learning and teaching science in grades K-8*. Washington, DC: The National Academies Press.

National Research Council. (2009a). *Engineering in K-12 education: Understanding the status and improving the prospects*. Washington, DC: The National Academies Press.

National Research Council. (2009b). *Learning science in informal environments: People, places, and pursuits*. Washington, DC: The National Academies Press.

National Research Council. (2011). *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics*. Washington, DC: The National Academies Press.

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press.

National Research Council. (2013) *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

Partnership for 21st Century Skills. (2011). *Framework for 21st Century Learning.* Retrieved from: http://www.p21.org/about-us/p21-framework

President's Council of Advisors on Science and Technology. (2010). *Prepare and inspire: K-12 education in science, technology, engineering, and mathematics (STEM) for America's future.* Retrieved from: http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stemed-report.pdf

President's Council of Advisors on Science and Technology. (2012). *Report to the President: Engage to excel: Producing one-million additional college graduates with degrees in science, technology, engineering, and mathematics.* Retrieved from: http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf

Tan, L. M., & Laswad, F. (2009). Understanding students' choice of academic majors: A longitudinal analysis. *Accounting Education, 18*, 233-253.

The Annie E. Casey Foundation. (2011). Double Jeopardy: How Third-Grade Reading Skills and Poverty Influence High School Graduation. Baltimore: Donald J. Hernandez. Retrieved from: http://www.aecf.org/resources/double-jeopardy/

Tyler-Wood, T., Knezek, G., & Christensen, R. (2010). Instruments for assessing interest in STEM content and careers. *Journal of Technology and Teacher Education 18*(2), 345-368.

LOGIC MODEL 2 REFERENCES

Blank, R. K., de las Alas, N., & Smith, C. (2008). *Analysis of the quality of professional development programs for mathematics and science teachers: Findings from a cross state study.* Washington, DC: Council of Chief State School Officers.

Bybee, R. W. (2013). *The Case for STEM Education: Challenges and Opportunities. National Science Teachers Association.* NSTA Press: Arlington, Virginia.

Darling-Hammond, L., Chung Wei, R., Andree, A., & Richardson, N. (2009). *Professional learning in the learning profession: A status report on teacher development in the United States and abroad*. Oxford, OH: National Staff Development Council.

Desimone, L. M., Porter, A. C., Garet, M. S., Yoon, K. S., & Birman, B. F. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis*, *24*(2), 81-112.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), 915-945.

Knight, J. & Cornett, J. (2009). *Studying the impact of instructional coaching*. Lawrence, KS: Kansas Coaching Project for the Center on Research on Learning.

National Center on Time & Learning (NCTL). (2011). *Strengthening Science Education: The power of more time to deepen inquiry and engagement.* Boston, MA: NCTL.

Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal*, *44*(4), 921-958.

Supovitz, J. A., Mayer, D. P., & Kahle, J. B. (2000). Promoting inquiry-based instructional practice: The longitudinal impact of professional development in the context of systemic reform. *Educational Policy*, *14*(3), 331-356.

Wenglinsky, H. (2002). The Link between Teacher Classroom Practices and Student Academic Performance. *Education Policy Analysis Archives*, *10*(12), n12.

LOGIC MODEL 3 REFERENCES

Achieving the Dream. (2014). (Website). Retrieved from: http://achievingthedream.org/

Association of Washington Business. (2013). *Washington State Center of Excellence: Addressing Skills Gaps, Creating Careers.* Retrieved from http://www.awbinstitute.org/docs/2013%20COE%20Report_vFinal_LR.pdf

Attewell, P., Lavin, D., Domina, T., & Levey, T. (2006). New evidence on college remediation. *Journal of Higher Education*, *77*, 886–924.

Bahr, P. R. (2008). Does mathematics remediation work?: A comparative analysis of academic attainment among community college students. *Research in Higher Education*, *49*, 420–450.

Bahr, P. R. (2010a). Preparing the underprepared: An analysis of racial disparities in post-secondary mathematics remediation. *The Journal of Higher Education*, *81*(2), 209-237.

Bahr, P. R. (2010b). Revisiting the efficacy of post-secondary remediation: The moderating effects of depth/breadth of deficiency. *The Review of Higher Education*, *33*(2), 177-205.

Bettinger, E., & Long, B. T. (2004). *Shape up or ship out: The effects of remediation on students at four-year colleges*. National Bureau of Economic Research, Working Paper No. W10369. Cambridge, MA: National Bureau of Economic Research.

Bettinger, E. P, & Long, B. T. (2008). *Addressing the needs of underprepared students in higher education: Does college remediation work?* Retrieved from http://gseacademic.harvard.edu/~longbr/Bettinger_Long_-_Addressing_needs_of_under_prepared_students_(4-08).pdf

Howell, J. S., Kurlaender, M., & Grodsky, E. (2010). Post-secondary preparation and remediation: Examining the effect of the Early Assessment Program at California State University. *Journal of Policy Analysis and Management*, *29*(4), 726-748.

Parsad, B., Lewis, L., & Greene, B. (2003). Remedial education at degree-granting post-secondary institutions in fall 2000. (NCES 2004-010). Washington, DC: National Center for Education Statistics.

Rutschow, E., and Schneider, E. *Unlocking the Gate What We Know About Improving Developmental Education*. Retrieved from http://www.mdrc.org/sites/default/files/full_595.pdf

Washington Roundtable and the Boston Consulting Group. (2013). *Great Jobs within Our Reach: solving the program of Washington State's growing job skills gap.* Retrieved from http://waroundtable.com/waskillsgap

Washington Student Achievement Council. (2013). *A Skilled and Educated Workforce 2013 Update. Joint Agency Report.* Retrieved from http://www.wsac.wa.gov/sites/default/files/2013.11.16.Skills.Report.pdf.

Workforce Development Council of Seattle – King County. (2011). *Talent Pipeline Study for Health Care, Manufacturing, Transportation and Logistics.* Retrieved from http://www.seakingwdc.org/pdf/other-reports/TalentPipeline-web.pdf

Workforce Development Council of Seattle – King County. (2012). *Talent Pipeline Study for Information Technology, Business Services, Finance and Insurance.* Retrieved from http://www.seakingwdc.org/pdf/other-reports/Talent%20Pipeline2-web.pdf

Workforce Training and Education Coordinating Board. (2012a). *High Skills, High Wages – Washington's 10-Year Strategic plan for Workforce Development.* Retrieved from http://www.wtb.wa.gov/Documents/HSHW2012StrategicPlan.pdf

Workforce Training and Education Coordinating Board. (2012b). *Washington Employer Survey: A Survey of Employer Needs and practices.* Retrieved from http://www.wtb.wa.gove/Documents/Employersurvey 2012-summary.pdf.

Workforce Training and Education Coordinating Board. (2013). *Skill Gap Analysis Identifies High Employer Demand Fields*. Retrieved from http://www.wtb.wa.gov/HighDemandFields.asp

LOGIC MODEL 4 REFERENCES

Stanford Social Innovation Review. (2011). *Collective Impact.* Retrieved from http://www.ssireview.org/articles/entry/collective_impact

Turner, S., Merchang, K., Kania, J., & Martin, E. Understanding the Value of Backbone Organizations in Collective Impact: Part 1 (Blog post). (2012, July 17). *Stanford Social Innovation Review.* Retrieved from http://www.ssireview.org/blog/entry/understanding_the_value_of_backbone_organizations_in_collective_impact_1

GENERAL REFERENCES

Banilower, E. R., Campbell, K. M., Malzahn, K. A., Smith, P. S., Weis, A. M., & Weiss, I. R. (2013). Report of the 2012 national survey of science and mathematics education. Retrieved from http://www.horizon-research.com/2012nssme/research-products/reports/technical-report/

Bybee, R. W. (2013). *The Case for STEM Education: Challenges and Opportunities. National Science Teachers Association.* NSTA Press: Arlington, Virginia.

Change the Equation. (2012). *Vital Signs: Washington*. Washington, DC. Retrieved from http://vitalsigns.changetheequation.org/tcpdf/vitalsigns/newsletter.php?statename=Washington

Committee on STEM Education. (2013). *Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan.* Retrieved from: http://www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf

Engrossed Second Substitute House Bill 1872, 28A RCW § 188 (2013).

Georgetown University Center on Education and the Workforce. (2011). *STEM*. Washington, D.C.: Carnevale, A. P., Smith, N., & Melton, M.

Mathison, Sandra (Eds.) (2005). *Encyclopedia of Evaluation*. Thousand Oaks, CA: Sage Publications.

Glascock, S. (2012, Spring). The cost of engineering's capacity problem. *The Trend in Engineering, Spring 2012*, 4-5. http://www.engr.washington.edu/news/trend/spr12_capacity.html

Institute for Computing Education. (2013). *Detailed data on pass rates, race, and gender for 2013* [Data file]. Retrieved from http://home.cc.gatech.edu/ice-gt/556

Massachusetts Department of Higher Education. (2009). *Massachusetts Statewide STEM Indicators Project (MASSIP)*. Boston, MA. Retrieved from http://www.mass.edu/stem/outcomes/datadashboard.asp

Scholastic and The Bill & Melinda Gates Foundation. (2014). *Primary Sources: America's Teachers on Teaching in an Era of Change* (3rd Ed.). Retrieved from http://www.scholastic.com/primarysources/PrimarySources3rdEdition.pdf

Washington Office of Superintendent of Public Instruction. (2014a). *Washington's 2014 State of the State Educator Survey Report: Summary of Key Findings.* Olympia, WA: Zhu, B., Yoder, N., Giffin, J., & Brandt, C. Retrieved from http://tpep-wa.org/wp-content/uploads/TPEP_StatewideSurveyReport_2014.pdf

Washington Office of Superintendent of Public Instruction. (2014b). *Washington Kindergarten Inventory of Developing Skills (WaKIDS)* [Data file]. Retrieved from http://reportcard.ospi.k12.wa.us/WaKidsDetailPage.aspx?domain=WaKIDS&groupLevel=District&schoolId=1&reportLevel=State&year=2013-14

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[i] See Washington Roundtable and Boston Consulting Group (2013).
[ii] See Institute for Computing Education (2013).
[iii] See Glascock, S (2012).
[iv] See Scholastic and The Bill & Melinda Gates Foundation (2014).
[v] See Washington Office of Superintendent of Public Instruction (2014a).
[vi] See Banilower, E. R., Campbell, K. M., Malzahn, K. A., Smith, P. S., Weis, A. M., & Weiss, I. R. (2013).
[vii] See Washington Office of Superintendent of Public Instruction (2014b).
[viii] See Bybee, R.W. (2013).
[ix] See Mathison, S. (2005).
[x] See National Center on Time & Learning (2011).
[xi] See Bybee, R.W. (2013).
[xii] See Washington Student Achievement Council (2013).
[xiii] See Workforce Training and Education Coordinating Board (2012).
[xiv] See Association of Washington Business (2013).
[xv] See Washington Roundtable and the Boston Consulting Group (2013).
[xvi] See Rutschow, E., and Schneider, E. (2011).
[xvii] See Stanford Social Innovation Review (2011).
[xviii] See Stanford Social Innovation Review (2012).
[xix] See Turner, S. (2012).
[xx] See Massachusetts Department of Higher Education (2009).

WASHINGTON STEM FRAMEWORK FOR ACTION AND ACCOUNTABILITY

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Jim Schmidt, State of Washington Office of Financial Management, Education Research and Data Collection
Gene Sharratt, Washington Student Achievement Council
Sally Shuler, Washington Informal Science Education (WISE) Consortium
Adie Simmons, Washington State Family and Community Engagement Trust
Bethany Sjoberg, Highline Public Schools
Susan Yang, Thrive by Five Washington