

## STEM AC Definitions and Concepts Paper

Professional learning is a critical component of educator development that is aimed at implementing educational reforms and/or impacting student achievement (Hiebert, Gallimore & Stigler, 2002; Webster-Wright, 2009). It is held that students directly benefit by improving the content knowledge and pedagogical skills of educators, but according to numerous researchers, teachers typically endure professional development (PD) that is expensive, episodic, and often meaningless (Darling-Hammond & Richardson, 2009; Newmann, King & Youngs, 2000; Soliday, 2015; Thomas, 2009). Despite this, as Guskey (2000) stated, “Never before in the history of education has greater importance been attached to the professional development of educators” (p. 3). If educators are the key to student achievement and success, then it is of the utmost importance that educator PD is done correctly. In an effort to provide “high quality educator science, technology, engineering and math (STEM) PD”, as indicated in Idaho Code §67-823, and to improve student outcomes in STEM, the Idaho STEM Action Center was legislated into existence in July 2015.

### **Background on the Idaho STEM Action Center**

During the 2015 Idaho legislative session, a small group of visionary legislators, education leaders, and industry stakeholders began a biweekly meeting referred to as “The STEM Caucus.” This group eventually crafted and guided through Idaho House Bill 302 that became law on July 1, 2015 (Idaho Code §67-823). This legislation created a new agency housed within the Executive Office of the Governor, the Idaho STEM Action Center (STEM AC). The legislation specifies the five broad areas upon which STEM AC would focus: 1) student learning and achievement (including achievement gaps and underrepresented populations); 2) student access to STEM including equity issues; 3) high quality STEM PD and teacher and student opportunities; 4) college and career STEM

pathways; and 5) industry and workforce needs. This law permits some flexibility for STEM AC to develop unique opportunities for educators, students, communities, businesses, and industries throughout Idaho from kindergarten through career.

Decisions related to STEM AC, including legislative intent and implementation, are guided by a nine member Board. The Board is comprised of two educational leaders from Idaho's Office of the State Board of Education (OSBE) and the State Department of Education (SDE) and seven from Idaho industry including the directors of the Idaho Department of Labor and the Idaho Department of Commerce. Other industry representatives are chosen by the Governor and selection is based primarily on industry-focus and geographic location. Currently, the industry members are Idaho National Laboratory (INL), the Micron Foundation, LCF Enterprises, Glanbia, and AlertSense/Idaho Technology Council.

With the five focus areas in mind, STEM AC Board members developed mission and vision statements. The mission of STEM AC is "Connecting STEM education and industry to ensure Idaho's long-term economic prosperity" and the vision is to "Produce a STEM competitive workforce by implementing Idaho's kindergarten through career STEM education programs aligned with industry needs."

During the 2015 legislative session, STEM AC was launched with \$647,000 to support the five target areas throughout Idaho. During the 2016 legislative session, STEM AC requested and was appropriated \$4.5M from the general fund. Why did legislators increase STEM AC's budget nearly seven-fold from fiscal year 2016 (FY16) to FY17? The need in Idaho communities and from Idaho educators and students proved to be significant, with only 22% of the funding requests filled during FY16. Legislators recognized the importance of STEM and allotted additional funds to support STEM education because of both the extreme need from educators and due to industry encouragement. As a result, \$2.5M was appropriated specifically for Idaho Code §67-823 to fully

implement STEM AC's original legislation. Moreover, because of industry input, the Computer Science Initiative (Idaho Code §33-1633) was successfully passed with significant bipartisan support. An additional \$2M in onetime funds was specifically ear-marked to implement the dictates in this initiative.

High quality STEM PD is not only mandated in Idaho Codes §67-823 and §33-1633, it is also absolutely essential to provide educators with the tools to help them inspire and prepare Idaho's future workforce by empowering students with not only the technical skills but also 21<sup>st</sup> century workforce skills such as critical thinking, problem-solving, collaboration, and innovation. In FY17, STEM AC has devoted over 20% of its budget (just over \$1M of its \$4.5M dollars) to high quality STEM PD; therefore, it is vital that STEM AC get this right! STEM AC must not only collect information from educators related to their PD experiences, but then must use the data to modify existing or develop new policies and/or programs to ensure that Idaho educators truly do receive the highest quality STEM PD.

Research related to STEM AC legislation and specifically to 'high quality STEM PD' will allow STEM AC to better implement projects and programs. Defining key terms will ensure legislative intent through clarifying definitions related to STEM, high quality STEM PD, traditionally underrepresented populations in STEM, typical pathways that students take that lead to a STEM career, and industry and workforce needs in STEM throughout the U.S and within Idaho. Common definitions will promote understanding and consistency within STEM AC, between STEM AC and its Board members, and among other agencies, including the legislature, local districts, educators (formal and informal), out of school entities, and Idaho communities. The research described here will guide STEM AC in the identification of desired outcomes and the selection of appropriate projects and programs to achieve those outcomes. The process will include collecting feedback from educators to determine if specific policies or programs are worth scaling and/or

sustaining. Specifically, the purpose of this research is to create a common language when communicating about STEM in Idaho.

Chapter 2 contains five major sections, each describing and outlining current research in one of the STEM AC focus areas listed above. After each section, a discussion will address how STEM AC can use existing data, along with other information collected in this research, to make relevant policy and programmatic decisions. It is critical that STEM AC use the funding in a consistent, transparent, and appropriate manner. Creating a common language around STEM AC programs requires defining frequently used terms. Using existing research to create a common language will allow STEM AC to convey clear and stable messages to all its stakeholders.

Chapter 3 will describe the research study in depth, including the research tools, the participants, the proposed methodology, and the proposed analysis to be used to answer the research questions. Specifically, this research is guided by the following research questions:

- 1) How do Idaho educators define ‘high quality STEM PD’?
- 2) In what ways is this definition similar to/different than the literature on 'high quality STEM PD'?
- 3) To what extent are STEM AC PD opportunities, selected via research-based rubrics, determined by Idaho educators to be of ‘high quality’?

## CHAPTER 2: DEFINING TERMINOLOGY RELEVANT TO STEM AC FOCI

Given the broad mandates outlined in Idaho Codes §67-823 and §33-1633, it is imperative that terms and concepts relevant to the major STEM AC foci be defined. Chapter 2 will discuss the variety of existing definitions and interpretations of specific terms and concepts, and then provide the definitions that have been adopted by STEM AC. Specifically, Chapter 2 will define:

- 1) STEM
- 2) High quality STEM professional development
- 3) Traditionally underrepresented populations in STEM
- 4) Typical pathways that students take which lead to a STEM career
- 5) Industry and workforce needs in STEM throughout the U.S. and within Idaho

### **Definition of STEM**

What is STEM? Many people can recite the words associated with the acronym STEM: Science, Technology, Engineering, and Math. However, various stakeholders often have significantly different conceptions of STEM. Breiner, Johnson, Harkness, and Koehler (2012) conducted a short, two question survey of university faculty to determine 1) How is STEM defined? and 2) How does STEM impact/influence life? STEM was defined simplistically by nearly all the faculty as science, technology, engineering, and math; however, conceptually, there were significant variations. To some, it was a very single-subject, segregated expression of content areas, such as chemistry *or* biology *or* physics *or* engineering *or* mathematics. Others described STEM as the integration of the fields (two or more disciplines), such as math *and* engineering. Still others focused on the need for STEM to mirror the practices of the profession which often include integration of the STEM fields as well as critical thinking and the ability to solve real-world issues. The authors indicated, “the way STEM is taught is often much different than the way STEM is done;” while STEM professionals “naturally practice integrated STEM and are less likely to compartmentalize

disciplines,” most K-12 classroom teachers do not necessarily teach STEM in this fashion (Breiner et al., 2012, p. 5). From a policy perspective, even many educational stakeholders, including the National Science Foundation, K-12 agencies, and school districts, considered STEM to be traditional disciplinary coursework (separate courses of science, mathematics, technology, and engineering), lacking an integrated approach (Briener, et al., 2012). According to Labov, Reid, and Yamamoto (2010) one of the most important modern conceptions of STEM education might be the idea of an integrated STEM approach that is practical and purposeful, which connects the STEM disciplines and is used to solve real-world problems.

Compounding the problem, these differing definitions of STEM often lead to significant variation in STEM spending estimates and STEM jobs reporting. For example, in a 2012 Congressional Service Report, it was estimated that federal spending and investment in STEM education programs was between \$2.8 billion and \$3.4 billion annually (Gonzales, 2012). The report indicated that the “differences between the inventories [values] are due, in part, to the lack of a common definition of what constitutes STEM” (p. 7). Not only are the estimated amounts of STEM spending vastly dissimilar because of differing definitions, but the estimated number of STEM workers also varies significantly. At a 2015 workshop entitled *Developing a National STEM Workforce Strategy*, Calvin Droegemeier, the vice president and general manager of Manpower’s northeast division, a company devoted to helping others find temporary and permanent employees, noted that,

...there is no consensus definition of the STEM workforce and it consists of many sub-workforces. One reason for the vastly different analyses about the state of the STEM workforce is because the definition of a STEM worker is not consistent from article to article and report to report. (p. 13)

Not only is the lack of a clear definition of STEM making it difficult to estimate spending and workforce counts at the federal level, but different definitions between agencies within the same state also cause estimates to differ from one another. This is especially true when estimating the STEM workforce and employer needs. Some agencies use a definition of STEM that includes health care and social science such as psychology and economics, in addition to the more traditional disciplines of sciences and engineering (Corbett & Hill, 2015; Gonzalez & Kuenzi, 2012; Kuenzi, 2008; Maltese & Tai, 2011). Others use a much narrower definition that excludes social sciences and health care. These different definitions often lead to significant variations in numbers when attempting to quantify spending and job reporting (Alper, Board on Higher Education and Workforce, Policy and Global Affairs, National Academies of Sciences, & Engineering and Medicine, 2015; Wang, 2013).

The disparities in definitions become particularly problematic when attempting to ‘target’ STEM efforts toward specific populations. For example, a 2007 report on women in STEM showed significant gender gaps in the number of women in STEM jobs and pay equity. However, this report used a very narrow definition of STEM, excluding majors such as business (i.e. economics), health care, and social sciences (i.e. psychology) (Beebe, et al., 2007). A different study by Wang and Degol (2013) used a broader definition of STEM to include physical and biological science, medical, health, computer sciences, engineering, and mathematics, and found smaller STEM gender gaps than Beebe, et al., (2007).

### STEM AC Definition of STEM

As indicated in Breiner, et al., (2012), STEM professionals practice integrated STEM on the job. Therefore, when STEM AC focuses on STEM, it means integration of *at least* two STEM subjects. The ability to integrate at least two areas of science, technology, engineering, math, and/or computer science should be illustrated when implementing projects and programs in order to ensure

that STEM AC is meeting the demands of Idaho's STEM employers. This integrated approach is not only practiced on the job, but will also allow STEM AC to differentiate itself from the State Department of Education (SDE). At the SDE, science, math, English language arts (ELA), health, PE, government, arts, and social sciences are directed by individual coordinators who assist with revising standards, supporting assessments, and providing PD related to their content area. In light of this, it is critical that STEM AC forge its own path in the world of integrated STEM PD and other STEM projects and programs. It is important that STEM AC not duplicate the efforts of the SDE which seems to view the disciplines as more segregated than integrated. STEM AC must focus primarily on projects and programs that are representative of a truly interdisciplinary approach to STEM education and workforce preparedness.

In addition, to promote consistency between STEM AC and the Idaho Department of Labor, a clear definition of exactly which professions are encompassed in the STEM workforce is also necessary. The Idaho Department of Labor often uses a very broad definition of the STEM workforce. According to the Idaho Department of Labor, the STEM workforce is made up of four subdomains (Appendix A). Subdomain 1 includes life and physical science, math, engineering, and information technology occupations. Subdomain 2 includes social science occupations such as economists, psychologists, geographers, and archeologists. Subdomain 3 focuses on architecture and architects. Subdomain 4 is grounded in health care and includes doctors, dentists, nurses, and other related health care professionals. In total, 184 occupations are defined by the Idaho Department of Labor as STEM-related and requiring STEM skills.

When implementing the policies and programs of STEM AC, it is important that STEM AC operates under a clear definition of STEM. Through adopting a broad, integrated definition of STEM aligned to the definition used by the Idaho Department of Labor, consistency will prevail when discussing STEM throughout Idaho.

## High Quality STEM PD

With the term STEM clearly defined, the term ‘high quality STEM professional development’ must next be defined as STEM AC legislation dictates that STEM AC “support high quality STEM professional development” (Idaho Code §67-823). In fact, this term is used seven times throughout the legislation, but there is no clear definition to indicate what the term “high quality STEM professional development” means. Because of the ambiguity and various definitions used in journals and by vendors, it is critical that STEM AC ensure a clear and transparent definition of high quality STEM PD for Idaho educators and other stakeholders. In addition, STEM AC has allocated significant funds to support this targeted effort throughout Idaho making it even more important to ensure consistency.

Regarding the potential range of PD opportunities, numerous articles discuss the need for teachers to receive ‘job-embedded professional development’ (Blank, de las Alas, & Smith, 2007; Darling-Hammond & Richardson, 2009; Saxe, Gearhart, & Nasir, 2001; Wenglinsky, 2000; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). Job-embedded PD is a type of PD in which educators have time to reflect upon and improve their practice through activities such as peer observations, analysis of student work, educator work groups, and/or professional learning communities (PLCs) (Darling-Hammond & Richardson, 2009). The job-embedded PD approach was used by Smith and Gillespie (2007) and compared to the traditional workshop-focused PD. They determined that the primary difference between traditional and job-embedded PD is that in traditional forms of PD, “outside experts do most of the talking and teachers do the listening” whereas, in job-embedded PD, “teachers do the talking, thinking, and learning” (p. 219). They concluded that, “If the goal is to increase teacher knowledge than traditional PD might work for some educators. However, if the goal is to increase student achievement, then job-embedded PD, situated in practice, is more likely to accomplish this task” (p. 215).

PD is also clarified in the Every Student Succeeds Act (ESSA, 2015) by defining that, “The term ‘professional development’ means activities that ... are sustained (not stand-alone, 1-day, or short-term workshops), intensive, collaborative, job-embedded, data-driven, and classroom focused” (S. 1177, Section 8002, page 295, paragraph 42) and that it provides “high quality, personalized professional development that is evidence-based” (S. 1177, Section 2103, page 127, paragraph E).

Job embedded PD is very different than single day ‘drive-by’ PD. Single-day PD ranks low amongst the most effective methods of delivery for PD; however, this ‘one and done’, single-day approach tends to be the most common type of PD that teachers experience (Darling-Hammond & Richardson, 2009; Stein, Smith, & Silver, 1999). According to a 2014 Gates Foundation survey, 80% of educators indicate they participated primarily in workshops as the most common form of PD and that they spend an average of 20 hours per year in these workshops even though this approach is less effective than job-embedded PD (Boston Consulting Group, 2014). To elaborate, in a study by Yoon, et al., (2007) nine different PD opportunities for educators were compared to student outcomes including student achievement. Educator PD lasting less than 14 hours showed no effect; whereas more than 14 hours showed a positive effect. However, the largest positive gains were found in PD that was between 30 to 100 hours and was spread out over a period of six to twelve months. These findings are similar to a study by Supovitz and Turner (2000) that found it was only after 80 hours of PD that teachers reported using inquiry-based, hands-on teaching strategies, which had positive impacts on student outcomes, at a significantly higher rate than those with less time spent in PD.

According to a study by Banilower, Smith, Weiss, Malzahn, Campbell, and Weis, (2013), science teachers spend, on average, less than 35 hours in PD over a three-year period. This was particularly true of elementary teachers who “rarely have the opportunity to collaborate with colleagues or participate in science-focused professional development” (p. 50). Numerous

researchers have recognized this is simply not enough time to truly develop professionally (Darling-Hammond & Richardson, 2009; Stotts, 2011; Supovitz & Turner, 2000; Wilson, Schweingruber, & Nielsen, 2016). Unfortunately, this ‘drive-by’ method of PD is the most common method because it is relatively inexpensive compared to long-term, sustained PD involving opportunities such as mentorship, coaching or the formation of professional learning communities (Brasiel & Martin, 2015; Darling-Hammond & Richardson, 2009; Flynn, 2013; Stotts, 2011; Wilson, et al., 2016.). The importance of on-the-job training, situated in practice, is illustrated in many professions including student teaching, apprenticeship programs, and numerous service jobs and should be consistently incorporated into educator PD (Alper, et al., 2015; Wilson, et al., 2016). Sustained PD is more time-consuming and/or cost intensive when compared to ‘one-and-done’ PD (Brasiel & Martin, 2015; Darling-Hammond & Richardson, 2009; Flynn, 2013; Stotts, 2011; Wilson, et al., 2016). In addition to the time required for delivery of sustained PD, often peer mentors/coaches are required, necessitating the reduction of teaching loads in order for educators to serve in this capacity (Stotts, 2001; Wilson, et al., 2016; Young, House, Wang, Singleton, & Klopfenstein, 2011). Consequently, administrators may not fully support this type of PD due to the intensity and/or expense (Darling-Hammond & Richardson, 2009).

This lack of administrative support is unfortunate because it is a critical yet often overlooked component of successful PD and must go beyond simple administrative encouragement. According to Hernandez and Brendefur (2003), three important conditions appeared to have an impact on the quality of integrated mathematics units produced by teacher-teams: “teachers’ teaching practices, school supports, and collaborative patterns” (p. 274). Effective school supports included appropriate resources such as materials, time to reflect on one’s own practices, and time to observe other teachers’ practices. The administration must be wholly committed to supporting teacher collaborative teams in order for teachers to receive the full gains from PD (Hernandez & Brendefur,

2003). Similarly, Supovitz and Turner, (2000) reported that science educators who felt more supported by their administration often have students engage in more inquiry-based investigations than those educators who feel less supported, highlighting the importance of administrator buy in and support.

In a synthesis of the research on educator PD, Darling-Hammond and Richardson (2009) found that successful PD:

- a) “Deepens teachers' knowledge of content and how to teach it to students;
- b) Helps teachers understand how students learn specific content;
- c) Provides opportunities for active, hands-on learning;
- d) Enables teachers to acquire new knowledge, apply it to practice, and reflect on the results with colleagues;
- e) Is part of a school reform effort that links curriculum, assessment, and standards to professional learning;
- f) Is collaborative and collegial; and
- g) Is intensive and sustained over time.” (p. 51)

Conversely, from the same article, unsuccessful PD:

- a) “Relies on the one-shot workshop model;
  - b) Focuses only on training teachers in new techniques and behaviors;
  - c) Is not related to teachers' specific contexts and curriculums;
  - d) Is episodic and fragmented;
  - e) Expects teachers to make changes in isolation and without support; and
  - f) Does not provide sustained teacher learning opportunities over multiple days and weeks.”
- (p. 51)

In addition to the key components listed above, another support found to impact the success of PD is collaboration with entities outside of the traditional school setting. Horn and Little (2010) followed a highly collaborative group of math teachers whose students consistently demonstrated significant gains in learning and advanced coursework. The educators cited external factors as being significant to their successes, namely the active participation in university-based PD, the opportunity to collaborate on university-led research projects, and strong professional networks.

To this point, all of the PD methods discussed involve face-to-face delivery. However, this mode of delivery may be impractical for teachers in rural or remote areas. One potential solution is virtual PD including coaching. McConnell, Parker, Eberhardt, Koehler, & Lundeberg (2013) conducted a study regarding the perceived effectiveness of virtual science PD which included the use of video conferencing and message boards. The educators reported that the virtual experience helped them gain new information, work more effectively in collaborative groups, and development new professional friendships. However, the educators indicated they still preferred face-to-face, but sustained virtual PD certainly appears to be a viable alternative to single day or no PD.

#### Definition of High Quality STEM PD and STEM AC

Using the research by Darling-Hammond and Richardson (2009), STEM AC should focus on the seven major characteristics of high quality PD including increasing educator content knowledge, applications of that knowledge, student activities and outcomes, educator reflection and collaborations, all of which are sustained and in-depth. In order to define this as high quality STEM PD, the focus of the PD must be STEM-based, defined as two (or more) STEM disciplines. As indicated previously, STEM AC's definition of STEM is an integrated approach necessitating that PD opportunities require an integration of *at least* two STEM subjects.

Idaho currently uses an in-depth, collaborative approach for PD in math and ELA. At this time, eight ELA coaches are supported through the SDE with legislative funding. Math specialists

are also supported through university collaborations and legislative funding. Activities supported by Idaho ELA coaches and math specialists include assisting teachers in implementing the Idaho Content Standards and assessments (formative, interim, and summative), serving as mentors, supporting development of new skills, applications of knowledge, and providing resources. Science coaches, however, remain non-existent in Idaho. This is not surprising as Banilower et al. (2013) noted that only 17% of elementary and middle schools and 22% of high schools across the nation reported having access to a science coach. This study also indicated that access to coaching in general is much less common in rural schools. However, there is mounting data supporting the effectiveness of the science coaching model (Kuenzi, 2008; Stotts, 2011; Supovitz, & Turner, 2000; Wilson, et al. 2016).

Yet another significant consideration around PD is the method of delivery. Although a number of studies cite that teachers prefer the face-to-face mechanism of PD (Brasiel & Martin, 2015; Wilson, et al., 2016), with Idaho's geographic distribution, it will be necessary to look into virtual and blended modes of delivery in order to reduce overall cost. It would be impractical to expect localized, content-focused PD to be able to effectively support all regions of the state. To assess different modes, comparability studies should be conducted to determine whether virtual or blended PD is as effective as in person. As indicated by McConnell, et al., (2013), while educators prefer face-to-face PD, there has been surprisingly little research conducted on comparability of face-to-face with virtual and blended models of educator PD especially in the area of STEM. In addition, incentives, such as teacher stipends, may increase educator participation and completion rates and ultimately, have a long-term impact on teacher practices and student outcomes and therefore, should also be measured.

As STEM AC begins to systematically support 'high quality STEM PD', it will be essential to create a rubric that clearly outlines the expectations of vendor- and university- delivered

opportunities for educators. Ensuring that PD is effective in the long-term may require that communities of practice be formed throughout the state as recommended by numerous researchers (Brasiel & Martin, 2015; Darling-Hammond & Richardson, 2009; Flynn, 2013; Lave & Wenger, 1991; Stotts, 2011; Wilson, et al., 2016). Communities of practice would allow educators to share what they are doing in their classrooms (both successfully and less successfully) and interact with others (often educators who experienced similar PD) who can support them and give them advice and encouragement.

In addition, the local administration must be informed of the opportunity to ensure not only encouragement, but also effective partnerships and adequate supports. This will likely look very different from school to school, and the supports may come in the form of resources, unique scheduling to allow teacher collaboration or stipends for those serving as mentor teachers.

High quality PD has been shown to be more effective if it is sustained and intense (Garet, Porter, Desimone, Birman, & Yoon, 2001), is immersive in experiments, inquiry and questioning with strong administrative support (Supovitz & Turner 2000), and demonstrates measurable outcomes (Brasiel & Martin, 2015). Therefore, it is important that STEM AC incorporate these critical elements in order to ensure that it is truly supporting effective statewide STEM PD and ensuring long-term successful outcomes.

### **Underrepresented Populations in STEM**

Traditionally underrepresented populations in STEM have been discussed by numerous authors with the primary focal groups including gender (women), geography (rural), minorities (including African American and/or Hispanic ethnicity) and low socioeconomic status (often identified by free/reduced priced lunch status as defined by the federal government) (Alper, et al., 2015; Beede, Julian, Langdon, McKittrick, Khan, & Doms, 2011; Cole & Esponzoza, 2008; Committee on Improving Higher Education's Responsiveness to Regional STEM Workforce Needs,

2016; Gonzalez & Kuenzi, 2012; Kuenzi, 2008; Malcolm, 2010; Morganson, Jones, & Major, 2010; Slotts, 2011; Walton, 2014). Each group presents a unique set of challenges in relation to recruitment and retention in STEM, kindergarten through career.

### Women as an Underrepresented Population in STEM

According to an economic briefing by Beede, et al. (2011), women fill nearly half of all U.S. jobs, but they hold less than 25% of the STEM jobs. However, the briefing uses a narrow definition of STEM, excluding health care, education, and social sciences. The briefing states,

There are many possible factors contributing to the discrepancy of women and men in STEM jobs, including: a lack of female role models, gender stereotyping, and less family-friendly flexibility in the STEM fields (p. 1).

It is noted that often times STEM career pathways are less accommodating for women who may cycle in and out of the workforce to raise a family. The report concludes that this strong gender stereotyping might discourage women from pursuing STEM education and STEM jobs altogether leading to the discrepancy between the percentages. Wang and Degol (2013) also found that the work/family ‘imbalance’ is a major factor turning women away from STEM careers.

If these factors are true, then why should women be encouraged to pursue STEM careers? In relation to pay equity, it is estimated that women in STEM make approximately 33% more than women in non-STEM jobs (Corbett & Hill, 2015). In addition, the gender wage gap is smaller for women in STEM professions than non-STEM professions. As Beede, et al. (2011) described, men consistently earn more money than women; however, in STEM jobs, women make 86 cents per each dollar men make or 14% less than men, on average. In non-STEM jobs, women make approximately 21% less than men. Another interesting point from the research is that engineering, which is dominated by men 7:1, has the “smallest regression-adjusted wage gaps” compared to other STEM

professions (p. 5). This translates into female engineers earning on average 93 cents per dollar compared to male wages or just 7% less than men.

While it is economically beneficial for women to enter STEM fields, many women still do not pursue these pathways – particularly in the U.S. as compared to other countries. In Malaysia, for example, women earn half of the computer science degrees while in Indonesia women earn half of the engineering degrees. However, in the U.S., women earn only 18% of the computing degrees and 19% of the engineering degrees (Corbett & Hill, 2015). Morganson, et al. (2010) believe this is due to STEM environments in the U.S. being male-dominated, very individualistic, and highly impersonal with the climate being referred to as “chilly.” For example, a Latina student described her experience in a male-dominated STEM classroom:

It can be intimidating when the professor asks a question. I’m afraid to raise my hand because I’m afraid to say something wrong. Being one of the few women in a class of mostly men is intimidating, and I’m afraid of giving the wrong answer and being laughed at. (Alper, et al., 2015, p. 35)

Droegemeier echoes this young Latina’s concerns and tries to provide some encouraging advice,

STEM is for everyone and STEM skills provide empowerment for individuals. Too often, women and students of color who may be struggling with a STEM course are encouraged to drop it and switch to something ‘easier,’ but this is exactly the wrong advice. They need to be challenged and encouraged and not treated as if they are not smart enough to get the job done. (Alper, et al., 2015, p. 17)

How can more U.S. women be encouraged to enter STEM? Women and girls who are interested in STEM should be encouraged and supported (Beebe, et al., 2011). Strong, positive female STEM role models/mentors are another factor that could increase female retention rates in

STEM pathways (Beebe, et al., 2011; Corbett & Hill, 2015; Morganson et al., 2010; U.S. Congress Joint Economic Committee, 2012). STEM career awareness at several levels (middle school, high school, and postsecondary) has also been shown to be ‘absolutely essential’ for encouraging females to enter nontraditional STEM careers (Morganson, et al., 2010). In addition, forming female study groups and taking similar classes with other females can help women navigate STEM pathways during postsecondary education (Morganson, et al., 2010). Once in a STEM career, employers should be flexible with women, many of who are not only working, but are also often serving as the primary caregiver for the family (Wang & Degol, 2013).

### Rural Geography as an Underrepresented Population in STEM

There are a variety of challenges for rural communities related to K12, postsecondary education, and industry. Rural K12 schools often face the challenges of finding (and retaining) STEM educators (Stotts, 2011; Walton, 2014; Wiebe, 2013). In addition, rural schools often lack STEM electives that are typically offered in larger districts. This is due to the lack of qualified educators and/or the lack of the numbers of students needed to fill these classes (Stotts, 2011). Also, because of the limited staff, there are often few opportunities for teacher collaboration and coaching. In turn, this reduces educator access to job-embedded PD, mentoring, reflection, and collaborative (content-focused) learning groups, which are more common in larger districts (Banilower, et al., 2013). Finally, rural communities often face difficulties with industry interactions and mentorship due to the lack of major industries (Walton, 2014). According to Wiebe, et al. (2013), “it is clear that all groups from these mostly rural, under-resourced areas could use additional support” (p. 7).

While the rural challenges are larger than both STEM and STEM AC, there are a number of approaches that could be taken to support rural populations. Teachers could benefit from online (virtual or blended) PD and students should be encouraged and supported when taking online STEM coursework (Wilson, et al., 2016). Some rural districts lack instructional resources including supplies

for hands-on STEM labs or technology (Brasiel & Martin, 2015). Providing grants and funding to access these resources could serve to close the equity gap. As mentors may be limited in rural areas, providing virtual mentors could connect rural areas to urban mentors (Alper, et al., 2015).

### Race/Ethnicity as an Underrepresented Population in STEM

According to an article by Malcolm (2010), Hispanic adults currently represent only 4.2% of the STEM workforce; however, this population represents nearly one half of the potential workforce (current school-aged U.S. population). This means there is an opportunity to significantly “enlarge the STEM talent pool” and “to strengthen the U.S. competitive condition in an increasingly knowledge-based economy” (p. 29). In Idaho, Hispanic adults are the largest minority population, making up 12% of its demographic and Hispanic students make up 17% of the K12 school-aged population (Pew Research Study, 2014). Therefore, in relation to Idaho’s demographics, focusing primarily on Hispanics would make sense for the state’s current demographics.

If the goal is to “enlarge the STEM talent pool,” then it is not enough simply to encourage minority students to enroll in postsecondary coursework. Cultural factors including relevance and congruity are critically important for retention of minority populations in STEM fields and must be addressed (Cole & Esponzoza, 2008). Cultural relevance involves educators working to ensure that students can relate course content to their cultural context; whereas, cultural congruity includes “factors such as peer and faculty support, and co-curricular involvement,” both of which have been shown to “play a role in the retention of [minority] student population” (p. 286). For minority students in STEM, it is important that “faculty or staff members, in particular, serve as role models and as examples of [minority] individuals who have successfully navigated the educational system” (Cole & Espinoza, 2008, p. 286). This echoes the findings of Bonous-Hammarth (2000) who found that minority students report leaving STEM because they feel there is a disconnect between their majors and the values shared by their peer groups outside of their majors. Both studies are supported

by the findings from the Committee on Improving Higher Education's Responsiveness to Regional STEM Workforce Needs (2016) indicating that minority role models are an important factor for retaining minority students in STEM pathways.

Community college might be the answer to creating cultural congruity as many minority populations often attend community college on their path to a STEM career (Alper, et al., 2016; Committee on Improving Higher Education's Responsiveness to Regional STEM Workforce Needs, 2016; Malcolm, 2010). In fact, Malcolm (2010) discovered that 61% of the all Hispanic students who hold bachelor degrees attended community college at some point during their postsecondary education. In addition, those students who were from a more disadvantaged background were even more likely to attend community college to earn an associate degree. It should be noted that while the number of minority STEM majors is still relatively low, more minority students are earning STEM degrees than ever before. According to Gonzalez and Kuenzi (2012), enrollment for Hispanic/Latino, American Indian/Alaska Native, and African American students in science and engineering “grew by 65%, 55%, and 50%, respectively” (p. 2). Even so, minority populations still remain significantly underrepresented throughout the STEM fields. From the industry perspective, as the minority population of the U.S. continues to grow, it would make sense to invest in recruitment of minority populations into STEM fields (Alper, et al., 2015).

#### Socioeconomic Status as an Underrepresented Population in STEM

Research has shown that students (especially minority students) with low socioeconomic status (SES) have significantly less representation in STEM, beginning in high school and then carrying through to postsecondary and onward into STEM careers (Corbett & Hill, 2015; Wang, 2013). Why do students with low SES leave (or never enter) STEM pathways? One reason could be the lack of access to rigorous STEM coursework (Wang, 2013). Another reason may be the lack of

awareness of potential STEM careers as students with low SES might not personally know STEM professionals (Alper, et al., 2015; Corbett & Hill, 2016; Wang & Dregol, 2013).

Kennedy (1998) found that teachers who worked with high percentages of low SES students had, “on average, significantly lower levels of both investigative culture and inquiry-based practices” and often used the more traditional lecture-style format when teaching STEM courses (p. 976). It could be that this general lack of hands-on STEM turns today’s 21st century learners with low SES away from traditional STEM subjects in K12. In reference to students with low SES, Barcelona (2014) stated, “we are failing to prepare large numbers of our young people for postsecondary education or training” (p. 864).

Once students with low SES leave high school, the financial challenges of postsecondary education are soon recognized. A study by Kienzl and Trent (2009) found that receiving financial aid was a major factor for students with low SES entering into longer duration/higher cost STEM fields. Wang (2013) found that persistence after the first year is critical for retention of low SES students in STEM. This underscores the importance of schools to inform students (especially those with low SES) about financial aid opportunities that are available for postsecondary education.

How can students with low SES be encouraged to persist in a STEM pathway? In K12, using culturally relevant, hands-on projects could lead to increased retention (Darling-Hammond & Richardson, 2009; Maltese & Tai, 2011). Holding family financial aid nights could help raise student and family awareness and generate family/peer support for STEM degrees, certificates and career options. In postsecondary education, finding supportive peer groups could help students be successful and persist in STEM (Cole & Espinoza, 2008). Throughout K12 and postsecondary, it is critically important for educators to educate and support all students regardless of SES.

STEM Action Center Definition of Traditionally Underrepresented Populations

In defining ‘traditionally underrepresented populations in STEM,’ STEM AC needs to be aware of Idaho’s different demographic populations and work to ensure that these populations are methodically supported while also seeking external guidance to capture the more challenging aspects of certain populations. As explained below, capturing information related to gender and geography will prove to be easier than race/ethnicity and SES. However, the focus of STEM AC should remain primarily on these four groups as the majority of research (illustrated previously) highlights these as being significantly underrepresented in STEM. Should other groups be identified through STEM AC’s work, this definition should be updated accordingly to reflect Idaho-specific data.

Working to bolster increased participation in STEM through STEM AC in relation to race/ethnicity will be challenging because racial identification is often not known outside of the formal K12 school setting. It would be possible to require that at STEM AC-sponsored events, the local grant recipients attempt to collect aggregate counts and percentages. For example, at a Family STEM event, STEM AC could request that attendance include not only a total count, but also aggregate numbers (or percentages) of different races/ethnicities. However, this type of data would likely not be collected in a systematic manner at each site and could prove inaccurate. Census data might be a better estimator, but certain populations may attend (or not attend) an event in a different ratio than census data would suggest. Even more difficult to capture is SES. It would be possible to use aggregate numbers of free/reduced lunch data reported by a school or district, but obtaining SES data could prove to be more difficult in programs that do not capture this information such as summer camps, family STEM events, library activities, after school activities, and student competitions.

Aggregate data will verify that classroom grants and educator PD opportunities target all four traditionally underrepresented populations. However, capturing this information from informal events may not be possible and proxy measures may need to be extrapolated based on self-report

race/ethnicity data, free/reduced lunch data or census data. While not ideal, it is critically important to attempt to capture the full impact of STEM AC projects and programs in supporting traditionally underrepresented populations in STEM. Using rubrics to score grant applications which contain additional points awarded to communities serving traditionally underrepresented populations in STEM may counter some of these issues and help to ensure that STEM AC can specifically impact these four focal groups.

In relation to postsecondary education, knowing that traditionally underrepresented populations often attend community college (Malcolm, 2010) is important in STEM AC's efforts to support diversification of the Idaho STEM talent pool. Continuing to expand STEM AC's effort to partner with community and technical colleges to support programs focused on recruitment and retention would likely increase the number of underrepresented STEM graduates earning associate degrees or certificates or transferring to university. Idaho-specific data will be collected to determine if this is a common pathway for minority and other underrepresented STEM students in Idaho colleges and universities.

By clearly defining and effectively monitoring Idaho's STEM target populations, STEM AC will be able to verify the effectiveness of STEM AC projects and programs and measure outcomes and impacts.

### **College and Career STEM Pathways**

Research indicates that from as early as middle school, student interest in pursuing a career in STEM becomes an important factor in providing the momentum that serves to carry students through STEM pathways (Cleaves, 2005). In fact, students who indicate interest in a STEM career in middle school are two to three times more likely to graduate college with degrees in STEM than their peers who do not indicate such an interest (Tai, Liu, Maltese, & Fan, 2006). Therefore, it is advantageous to better understand factors that impact STEM pathways and how to cultivate interest in STEM.

### Major Factors That Favorably Impact STEM Pathways

According to a longitudinal data review (8th grade through college) by Maltese and Tai (2011), students who study STEM in college (community college or four-year university), have often made that choice by high school. They concluded that this choice is based on the following:

- Students' interest in STEM;
- The perception that math and science is challenging;
- The perception that they have a strong ability in math and/or science;
- Higher 8th grade math and science scores;
- Teacher enthusiasm;
- Engaging lessons that are hands-on with group discussions and few lectures;
- Relevance to real-life topics with student choice;
- Discussions about potential careers in science;
- Working in groups (which showed a positive impact on attitudes for female and

minority students). (p. 881 – 885)

By 12th grade, the study found those who indicated they planned to major in a STEM field in college were then four times more likely to actually complete a STEM degree (Maltese & Tai, 2011). This finding is supported by research from Wang and Dregol (2013) who found the intent to major in STEM was positively correlated with exposure to math and science courses as well as the belief that it is possible to be successful in math. Conversely, students who reported that their teacher lectured more and that they had more bookwork did not persist in STEM.

The conclusion of the Maltese and Tai study (2011) sums up the importance of early STEM education, “When [our] model is pared down to include only variables maintaining significance, it is evident that early indication of interest in STEM is associated with completion of a STEM degree” (p. 898). In fact, although fewer students from (non-Asian) minority groups completed a STEM

major overall, this study suggests that “once in college the likelihood of students earning STEM degrees is equivalent, regardless of demographic background” (p. 899). This is critically important in that it indicates the significance of early STEM education for all students; once a STEM-interested student enters postsecondary with the intention of majoring in STEM, they often do, in fact, complete the degree regardless of race/ethnicity or gender.

### How Can STEM Interest Be Achieved?

A number of studies have explored appropriate ways to achieve STEM interest with today’s 21<sup>st</sup> century students, via increasing relevance, raising STEM career awareness, and providing mentors with backgrounds similar to the students’ (Cleaves, 2005; Maltese & Tai, 2011; Rivet & Krajcik, 2007; Tai, et al., 2006). By utilizing projects that involve real-world investigations of STEM concepts, students have the opportunity to make the material relevant and applicable (Rivet & Krajcik, 2007). It is crucial that math and science curriculum be applicable to the students’ lives because this will maintain student interest in STEM (Matlese & Tai, 2011).

In addition to focusing on relevant, project-based learning approaches, more emphasis could also be placed on middle school STEM career awareness. Matlese and Tai (2011) found there is a strong positive correlation between educators who discuss STEM careers and student interest in pursuing a STEM career. In fact, many middle school students often are not aware of the variety of STEM career choices and may not personally know any currently practicing STEM professionals (Alper, et al., 2015; Corbett & Hill, 2016; Kier, Blanchard, Osborne, & Albert, 2014; Wang & Dregol, 2013).

Mentoring relationships also offer an opportunity to expose students to STEM professionals. “If every person mentored one student, think of the impact that would make,” said Debra Stewart, former president of the Council of Graduate Schools at the 2015 workshop *Developing a National STEM Workforce Strategy*. “Imagine, then, if that became a national theme—if each STEM

professional mentored a student” (p. 95). She proposed creating an inexpensive web-based infrastructure where students could select a STEM professional as a mentor and use e-mentoring via Skype and other technologies to expose students of all ages to the many careers available in STEM.

Research focusing on mentorship and minorities has demonstrated that some traditionally underrepresented populations respond well to mentors who are similar to themselves (Alper, et al., 2015; Cole & Espinoza, 2008; Committee on Improving Higher Education's Responsiveness to Regional STEM Workforce Needs, 2016; Kuenzi, 2008; Morganson, et al., 2010; National Governors Association, 2011; Office of Education Access and Success, 2012; U.S. Congress Joint Economic Committee, 2012). Mentorship has also been shown to be successful in a number of forms including face-to-face, virtual and blended (Alper, et al., 2015; Corbett & Hill, 2015).

#### Role of STEM AC in College and Career Pathway Selection by Students

Research indicates that STEM interest should be cultivated by STEM AC using a variety of methods. First, STEM AC should seek to increase student interest in and awareness of STEM and STEM careers. It should not only focus on community STEM events to increase STEM awareness, but should also support STEM career awareness events targeting middle school students as research indicates this is a critical time to build career awareness. Secondly, classroom or project-based STEM mentors should be leveraged to create awareness. By working with local businesses and matching classrooms to industry mentors, STEM AC could help inform students about potential STEM career options as well as giving them the opportunity to work on real-world projects with a STEM mentor.

Finally, STEM AC should also sponsor competitions that bring together students, educators, and industry mentors around a specific project or event, serving as a bridge between students and industry mentors. As with PD, STEM AC needs to be keenly aware of the geographical distribution

of educators, students, and STEM professionals in order to create opportunities that will meet the needs of Idaho's diverse and dispersed population.

### **STEM Needs in Industry and Workforce**

Idaho is facing a crisis: citizens are not entering STEM pathways at a rate that will sustain Idaho's continued economic development and future prosperity. According to a report by the Idaho Department of Labor, by 2025 Idaho will be lacking over 63,000 individuals needed to fill projected positions ranging from construction and service jobs to medical and technology positions, many of which involve STEM-related fields (Shaul & Uhlenkott, 2014). This fact illustrates that strengthening Idaho's STEM pathways is an urgent supply and demand issue. On one hand, workers looking to enter a STEM field have a large selection of jobs from which to choose. On the other hand, Idaho STEM industries and businesses are unable to fill their demand for STEM-skilled workers.

This shortage of STEM workers in Idaho and across the country has raised economic concerns about the ability of the U.S. educational system to produce a large enough workforce to fill the STEM workforce need (U.S. Congress Joint Economic Committee, 2012). Many see this as a pressing requirement to immediately increase efforts to recruit and retain students in STEM pathways (Boothe & Vaughn, 2009; Breiner, et al., 2012; Committee on Improving Higher Education's Responsiveness to Regional STEM Workforce Needs, 2016; Corbett & Hill, 2015; National Governors Association, 2011; Office of Education Access and Success, 2012). Idaho is meeting this challenge head-on by increasing the appropriation to STEM AC to \$4.5M during FY17 in an effort to increase STEM retention, recruitment, and the supply of workers that possess STEM-savvy 21<sup>st</sup> century workforce skills.

### **STEM Skills Gaps**

Research points to the fact that there is a disconnect between the needs of industry and the preparation of the future workforce in K16 programs. This is not just a technical skills gap, but also a soft skills gap. Soft skills are also known as 21<sup>st</sup> century skills and are defined by employers to include critical thinking, problem-solving, collaboration, teamwork, innovation, and creativity. Many of these skills gaps could be addressed through increased communication between K12, postsecondary, and industry.

At a September 2015 workshop entitled *Developing a National STEM Workforce Strategy* and hosted by the National Academies of Science, 150 participants discussed some of these STEM skills gaps. The attendees included a wide variety of experts in STEM fields (academic and research) and workforce development specialists from a variety of STEM industries throughout the U.S. From this workshop, numerous potential solutions were developed with the intention of serving as a roadmap to increase the number of individuals pursuing STEM pathways and entering into a STEM career, while also reducing the STEM skills gaps that currently exist. National Science Foundation Director Frances Córdova said,

We have little data indicating what [technical] skills employers require of new graduates entering the workforce. There is a clear need for communication about workforce training expectations between business and higher education, and perhaps no one cares more about this than the very students we educate—the millennials. (p. 4)

This quote illustrates the need for increased conversations between industry and post-secondary institutions (including trade and certificate schools and community colleges) to ensure that these technical STEM skills are clearly recognized, defined, and ultimately implemented into postsecondary instruction with systematic revalidation to confirm that postsecondary institutions keep up with the ever-changing needs of STEM industries. While technical skills are lacking in some STEM graduates, soft skills gaps were also mentioned a number of times. Emphasis was again

placed on addressing this mismatch by systematic discussions between postsecondary institutions and businesses.

A final topic discussed at the workshop focused on the need for K12 to partner and collaborate with higher education to ensure that students are prepared for life after high school. It is estimated that in Idaho 60% of the jobs in 2020 will require college and/or training beyond a high school diploma (Idaho Department of Labor, 2014). Therefore, as noted by numerous participants in the workshop, successful K12-university partnerships should be assessed for transferability and scalability.

Another report entitled *Promising Practices for Strengthening the Regional STEM Workforce Development Ecosystem* (Committee on Improving Higher Education's Responsiveness to Regional STEM Workforce Needs, 2016) discussed similar recommendations in relation to the need for increased communication between postsecondary and industries to reduce both the technical and the soft skills gaps. This report cites the importance of giving students real-world, hands-on experiences with industry especially during the postsecondary years. The key focus of this report was

...how to create the kind of university-industry collaboration that promotes higher-quality college and university course offerings, lab activities, applied learning experiences, work-based learning programs, and other activities that enable students to acquire knowledge, [technical] skills, and attributes [soft skills] they need to be successful in the STEM workforce. (p. 1)

The report concluded that while students have degrees in STEM, many lack the requisite technical and soft skills to be employable. Echoing other research, this report also found that “there is also a growing need for students with a breadth of skills outside of their core STEM discipline, these include problem solving, critical thinking, teamwork and collaboration, communication, and creativity” (p. 2). These findings mirror the discussion that occurred at the *Developing a National*

*Workforce Strategy* conference, in which industries agree that both technical and soft skills are lacking in many STEM graduates and increased collaboration between K12, postsecondary, and industry could serve to effectively address this issue.

Currently, there truly is a vast divide between what employers ascertain as ‘student preparedness’ to enter the workforce and what colleges and universities believe. Busted (2014) found that only 11% of business leaders indicate that “college graduates are well prepared for success at work” (p. 1). This is in stark contrast to the views of chief academic officers of colleges and universities of whom 96% indicate that they are “either somewhat or very confident they are preparing college students for success in the workplace” (p. 1). Regardless of the perceived lack of preparedness by employers, there is still a great advantage in possessing a STEM degree. Often graduates find that STEM knowledge and STEM skills transfer to a wide variety of non-STEM sectors, allowing them to be highly flexible, easily transferrable, and mobile. The benefit of a STEM degree means that there are many more viable job options for students than for those with non-STEM degrees (Apler, et al., 2016).

### Strengthening STEM Pathways

Droegemeier stated at the 2015 *Developing a National STEM Workforce Strategy* conference that,

...policymakers need to be thinking beyond a distinct and separate STEM workforce and instead be discussing what it would take to create a *STEM-capable* U.S. workforce. By fostering such a workforce—composed of individuals with distinct career interests and aspirations who require different educational and training opportunities throughout their careers—will require government, educational institutions, and businesses to fulfill their individual and collective responsibilities to assess, enable, and strengthen career pathways for all students and incumbent workers. (p. 18)

Droegemeier was emphasizing the need to focus on the acquisition of STEM skills and knowledge (through education and workforce training) by all individuals and that while people may take unique paths, the overarching goals should be to create individual opportunity and national competitiveness.

Greg Camilli, professor of educational psychology at Rutgers University's Graduate School of Engineering, expanded on those comments by adding, "We are far from a policy consensus on what constitutes 'high demand' [STEM jobs], and we have not as a nation effectively addressed how to reorient the funding agencies to address a global knowledge-based economy" (p. 39). In this, Camilli was suggesting it might be time to evaluate federal and state funding (or lack of funding) of STEM and potentially shift funds into high demand areas, such as computer science.

According to another report entitled *Promising Practices for Strengthening the Regional STEM Workforce Development Ecosystem* (Committee on Improving Higher Education's Responsiveness to Regional STEM Workforce Needs, 2016), numerous activities could strengthen entry into STEM pathways. To begin, businesses should "prioritize the development of as many work-based learning opportunities as possible for students and faculty—including paid internships, apprenticeships, and other experiences that provide hands-on, experiential learning at the worksite" (p. 3). To accomplish this, the report advises student and faculty experiences should be paid and should encourage diversity to increase the number of minority populations entering STEM fields. The report also advocates for partnerships among stakeholders and suggests that businesses support employees who want to serve as mentors especially to traditionally underrepresented populations in STEM including involvement in student projects.

In the same report, universities are encouraged to "work with local business leaders and others to 'take stock' of local employer workforce needs, and make a public commitment to better aligning the university's education programs, labs, curricula, and applied learning experiences to future STEM workforce projections" (p. 3). Universities are also encouraged to provide real-world

job experiences. “Changing the way STEM education takes place is an area in which corporate America should exercise its influence,” said Lida Beninson, an American Association for the Advancement of Science and Technology policy fellow working at the National Science Foundation (Alper, et al., 2015, p. 43). Echoing this statement, the founder and CEO of Ted Childs, a workforce diversification company agreed, “Companies are getting involved in education reform and training because they realize the talent they need tomorrow will not be there if the status quo holds” (Alper, et al., 2015, p. 43).

#### How Will STEM AC Address the Needs of Industry?

While creating STEM jobs and ensuring a healthy economy are much larger than STEM AC, the creation and funding of STEM AC indicates Idaho is on the right path to “reorient[ing] the funding” and ensuring that STEM receives the dollars necessary to continue to grow Idaho’s (and the nation’s) economy. The funding increase to STEM AC in FY17 certainly indicates that Idaho is willing to support STEM throughout the state. In FY16, STEM AC’s appropriation allowed approximately \$270,000 to flow out of STEM AC, primarily in the form of grants, community STEM events, and PD opportunities. The FY17 appropriation will move about \$4 million dollars into Idaho’s STEM pathways, kindergarten through career, allowing STEM AC to expand its projects and program while implementing new opportunities. Doing this in a disciplined fashion with tangible outcomes is absolutely essential.

It is also important to note that the multiplier effect of STEM jobs is tremendous. According to Enrico Moretti (2013), for every STEM job that is created, the multiplier effect is approximately five other jobs. Moretti’s research suggests that these five additional jobs are both professional, such as doctors, lawyers, nurses, and teachers, and nonprofessional, such as waiters and store clerks (p. 60). As a result, focusing on bolstering well paying, high demand STEM jobs could have a ripple effect throughout Idaho’s economy.

STEM AC must also evaluate regional and local incentives that would result in education-industry collaborations. This could be accomplished through grant partnerships involving STEM AC, university, and industry. Looking to facilitate and expand “educators in industry” and “industry in the classroom” could also improve understanding and open dialogues between groups. Working with the Idaho Department of Labor to better understand workforce development and industry sector grants will ensure that there is not duplication of efforts while also promoting collaboration between agencies and local communities. By increasing communications and interactions between K12, postsecondary, and Idaho industries, STEM AC can help ensure that the students of today have both the technical and soft skills for the STEM jobs of the future.

As indicated by Busteed (2014), the perceived “skills mismatch” between employers and postsecondary institutions should be openly discussed by Idaho industries and institutions in order to ensure that students enter the workforce with not only the technical skills, but also the soft skills which are required to be successful in the workplace. Perhaps a meeting that brings together these groups could be facilitated by STEM AC in an effort to foster these tangible connections.

Another potential solution in Idaho could be a university-industry co-op program. On a recent visit to the University of Waterloo in Canada, an Idaho delegation made up of university computer science representatives and government officials discovered the potential benefits to both students and employers via a co-op system. Through this model, college students would experience four months of full-time work without the additional burden of coursework. These work experiences would be incrementally integrated throughout their college career, giving students rich work-based skills that will prepare them to enter the workforce with both the technical and soft skills that businesses claim are currently lacking. With this in mind, STEM AC will look to partner with Idaho universities and focus on computer science in the upcoming year by piloting a university-industry co-op model in an effort to improve not only the employability skills of students, but to also provide

industries with a series of employees that can fill full-time positions. This university-industry pilot program could serve as a model to close some of the employability and skills gap issues.

As summarized by Busted (2014), “schools and colleges don’t have jobs and internships—employers do. If we don’t get schools and businesses working together to give students these opportunities, everyone will lose” (p.1). Therefore, actively connecting these groups is going to be critical to the long-term impacts of STEM AC and the effects of STEM workforce-preparedness throughout Idaho.

### **Conclusion**

STEM AC has a unique opportunity to expand and support STEM throughout Idaho. By deriving clear and consistent definitions of STEM, high quality STEM PD, and traditionally underrepresented populations in STEM as well as understanding STEM pathways and industry/workforce needs, STEM AC will be able to provide more targeted, consistent, systemic support. Through clearly defining high quality STEM PD, STEM AC can ensure that opportunities meet the needs of Idaho educators and ultimately, maximize students’ persistence in STEM pathways. Evaluating the needs of Idaho industries and businesses and working to bring groups together could serve to increase the number of STEM students prepared to enter the workforce upon completion of postsecondary programs. By continuing to work with Idaho industries, postsecondary institutions, and the K12 system to incorporate more workforce readiness projects, it will be possible to meet the goals and objectives outlined in STEM AC’s Strategic Plan (Appendix B).

Broadly speaking, the most critical piece of the puzzle at this time is educator PD. Educators need tools to successfully implement STEM coursework, to inspire students with hands-on, real-world projects, and to have access to industry mentors to ensure that students persist in STEM pathways and perhaps through to a STEM career. That is why during FY17, 25% of STEM AC’s budget will be devoted to K12 STEM PD. This means that in FY17, STEM AC anticipates it will

spend approximately \$1 million dollars on STEM PD. Consequently, every aspect of PD must be critically analyzed, from selection and implementation, to teacher evaluations and outcomes of both teachers and students. Synthesizing the literature on this topic and defining related key terms serves as an important first step in forming structures that will support these efforts. Moretti (2013) summarized it best, “We are at one of those major historical crossroads that determines the fate of nations for decades to come.” Applying this to Idaho, the work of the STEM AC will determine the fate of STEM in Idaho for decades to come.

## CHAPTER 3 – METHODS

Educator PD is of primary importance for not only the educator, but also for the students they serve. Done correctly, PD has the ability to transform teaching practices and impact student outcomes (Darling-Hammond & Richardson, 2009; Stotts, 2011). PD is important throughout the entire education system, but some elements are unique to *STEM* PD. For example, the interdisciplinary, hands-on, practical application of STEM impacts many facets of student experiences inside and outside of the classroom as well as after graduation (Alper, et al., 2015; Barakos, Lujan, & Strang, 2012). Therefore, ensuring that educators have the opportunity to gain, expand or improve skills in STEM education is critically important.

The primary goal of this research is to determine if the opportunities provided to Idaho educators by STEM AC are of high quality as defined by the educators who participate in the opportunities. Specifically, this research is guided by the following questions:

- 1) How do Idaho educators define ‘high quality STEM PD’?
- 2) In what ways is this definition similar to/different than the literature on 'high quality STEM PD'?
- 3) To what extent are STEM AC PD opportunities, selected via research-based rubrics, determined by Idaho educators to be of ‘high quality’?

Chapter 3 will begin by describing adult learning theory, which guides this research. Then the chapter will transition into a discussion of the research project itself, including a detailed description of the research-based rubrics, the participants in the study, and the methods used to answer the research questions.

### **Adult Learning Theory**

This research is anchored in adult learning theory, as the focus will be adult educators who will receive PD in a STEM-related area from a STEM AC opportunity. The most prominent theorist

to focus on the individual adult learner was Malcolm Knowles (1980), who popularized the term *andragogy* which is defined simplistically as the art and science of teaching adults. He viewed this learning theory to be unique to adults and different from child learners. Knowles' assumptions of adult learners include the following concepts:

- 1) Adults tend to be self-directed, independent, and internally motivated.
- 2) Adults have diverse knowledge and experiences upon which to draw.
- 3) Adults tend to learn best when learning is problem-centered and relevant.
- 4) Adults have a strong need to know the reasons for learning. (Knowles, 1980; Knowles, 1984; Knowles, Holton & Swanson, 1998)

It follows, then, that PD experiences supporting these assumptions might be perceived to be of higher quality than those experiences that do not support these assumptions. Merriam (2001b) believed that Knowles' ideas capture the general characteristics of adult learners and that his characteristics offered some guidelines for practice in relation to adult teaching and learning. In fact, some of the most successful adult education and PD programs meet the needs of individual adult learners by focusing on greater autonomy and self-direction, as originally suggested by Knowles (Merriam and Caffarella, 1999; Merriam, 2001b). Hartree (1984) suggested perhaps Knowles' characteristics are best practices of "what the adult learner *should* be like" (p. 205) and PD focused on these critical areas would most likely have an impact on the adult learner. Knowles' assumptions have been explored by numerous researchers and appear to be valid even for the 21<sup>st</sup> century adult learner.

Knowles suggested that adults possess certain characteristics related to their desire to learn including internal motivation, self-direction, and independence. Numerous researchers have supported these findings. Merriam (2004) discovered that adults have the abilities of "recognizing and maximizing opportunities and resources within their own environment" (p. 204) because they

are self-directed and motivated to improve their practice. David and Patel's model (1995) for adult learning predicts the most "potent motivators" of adults will be internal including "self-esteem, recognition, better quality of life, and greater self-confidence" (p. 358) which also supports Knowles' assumptions. Often adult learners tend to be very self-directed in their daily lives and as a result are perceived as being capable of taking responsibility for themselves, including for their learning (David & Patel, 1995). In fact, Desimone (2009) contended that some of the most important applications of PD occur when teachers returned to the classroom, applied the learned methodology and reflected upon on their own practice. This is an excellent example of educator self-direction and independence.

In the same vein as Knowles, David and Patel (1995) determined "adults enter into an educational activity with greater volume and different quality of experience from youth; adults are themselves a rich resource for one another" (p. 358) and the ability to share these experiences can actually strengthen the PD opportunity. Smith and Gillespie (2007) reiterated the essential need for PD to account for past experiences by purposely relating new learning to past understandings and illustrating applicability of the new learning outside of the PD setting. Similarly, in order for adults to learn, Mezirow (1996) suggested that transformational learning is critical. In this, adults attempt to make sense of their experiences, some of which might require adults make monumental shifts in beliefs or attitudes which in turn shifts their entire perspective. In order for this shift to occur, adults must believe that the learning is relevant to their life. Putnam and Borko (2000) found educational research supports the notion that PD should be "active, situated, and social," which could be interpreted as problem-centered (i.e. active and social) and relevant (i.e. situated). Comparable findings have been recorded in other research studies indicating professionals learn through practical experiences and that reflection has a valuable role in adult learning (Day, 1999; Garet, et al., 2001; Lieberman & Miller, 2001). While some studies use the term "practical experience," Knowles used

the term “relevant.” In addition, problem-centered learning is an approach that has been demonstrated as the way that adults learn most effectively especially when the focus of the problem is relevant to the adult’s situation (David & Patel, 1995).

According to a research report by Council of Chief State School Officers (CCSSO, 2008), there are five critical characteristics of successful adult PD including job-embedded, results-driven, content-rich, standards-based, and school-centered. A number of these characteristics are similar to Knowles’ characteristics of adult learners in relation to relevance.

Resnick (1987) proposed adults learn best when situated in an authentic activity rather than a simulated activity, resonating Knowles’ idea that adults need to have a clear understanding of why they are learning. The work of Lave (1996) and Lave and Wagner (1991) also stressed the importance of adults engaging in actual practice to truly understand why the learning is important.

Summarizing a variety of Knowles’ assumptions including relevance, problem-centered, and reasons for learning are Smith and Gillespie’s 2007 research that indicated the most effective PD is of

...longer duration, makes a strong connection between what is learned in the PD and the teacher’s own work context, helps the teachers plan for application and to identify and strategize barriers to application, focuses on subject-matter knowledge, includes a strong emphasis on analysis and reflection, rather than just demonstrating techniques, and should include a variety of activities. (p. 218)

### Challenges of Adult Learning

There are a number of challenges associated with adult learning theory research. First, research on adult learning theory is vast, complex, and diverse (Merriam, 2001a; Merriam & Caffarella, 1999). According to Merriam (2004), “after some 80 years of study, we have no single answer, no one theory or model of adult learning” that explains all that we know about adults as

learners (p. 199). However, “there is an ever-expanding understanding of what adult learning is and can be (Merriam, 2008, p. 98). Webster-Wright (2009) argued that because such time, effort, and expense go into educator PD, instead of focusing simply on “how best to provide PD activities” the system must begin to focus on “understanding more about the fundamental question of how professionals learn” (p. 705).

Another challenge as described by Merriam (2008), is that adult learners are an “ever-changing mosaic, where old pieces are rearranged and new pieces added” (p. 94). Mackeracher (1996), described adult learners like a “kaleidoscope,” a dynamic and interconnected complex set of processes that are interwoven into every aspect of the adult life experience including learning. Because adults often bring a wealth of personal knowledge and perceptions, learning is grounded in past understandings as adult learners search for relationships and commonalities between new and past experiences (Martin & Schifter, 1991) which need to be accounted for in order to have the most effective PD.

Yet another challenge according to Elmore (2002) is that it is a “gargantuan task for teachers to apply what they have learned in an off-site workshop once back in their classrooms and isolated from other teachers” (p. 25). Therefore, giving adult educators time to reflect on and to share their experiences with others will be an important consideration for STEM AC-supported PD opportunities.

As suggested above, how adults learn is important as related to high quality educator PD. However, perceptions of learning and high quality PD may vary significantly from one educator to another. Because of this inherent variability, there will be challenges in measuring adult learning and certain concepts may be difficult to capture using only quantitative techniques.

### Reasons to Measure Adult Learning

It is important to measure adult learning using an actual theory and assumptions associated with that theory because it will allow the study to focus on certain aspects of adult learning as associated with STEM PD. It is hypothesized that the two research-based rubrics did indeed select PD that adults will perceive to be of high quality. The next step is to have educators participate in the PD and provide feedback so data can be collected and analyzed in relation to adult learning theory and PD perceptions. Although the study of adult learning has a number of challenges, attempting to measure outcomes from learning is important in order to determine impacts on the adult learner. In fact, numerous occupations understand the imperative need for ongoing PD in order to maintain high quality practice, and teaching is no exception (Friedman & Phillips, 2004). It is also important that the PD is effective, efficient, and evidence-based in order to improve outcomes for both the teachers and the students (Garet, Porter, Desimone, Birman, & Yoon, 2001; Penz & Bassendowski, 2006).

In conclusion, Webster-Wright (2009) applauded adult learners because

...much of the research reveals most professionals as enthusiastic learners who want to improve their practice. Let us listen to their experience and work to support, not hinder, their learning. Rather than deny, seek to control or standardize the complexity and diversity of professional learning experiences, let us accept, celebrate and develop insights from them. (p. 727)

Therefore, supporting professional development opportunities where educators are given significant support and control of their learning is of the utmost importance. When studying the learning of adults, it is important that attempts are made to capture the nuances by using both qualitative and quantitative metrics. If adult learning is like a “mosaic” or “kaleidoscope”, then it is even more essential that educators are provided the opportunity to voice their opinions in order to better understand their perceptions of PD experiences and their associated learning.

## Research Methodology

This research uses a mixed methods approach, utilizing both qualitative and quantitative data collection and analysis techniques. Data will be collected from anonymous surveys, focus groups, and PD-specific pre- and post-survey analyses. For this study, it is anticipated that equal weight will be given to the qualitative and quantitative analysis and that both data type will be collected simultaneously. As explained by Johnson and Onwuegbuzie (2004), efforts will be made to ensure QUAL + QUAN data is collected in an equal and concurrent fashion. Further, according to research by Johnson and Onwuegbuzie (2004) and Teddlie and Tashakkori (2006), deciding the weighting of the QUAL + QUAN components in a mixed methods study is important to determine prior to undertaking the study to ensure that data is collected and analyzed with the end goal in mind. Johnson and Turner (2003) emphasized the importance of the mixed methods approaches and referred to the art of combining these qualitative and quantitative methods, so as to lead to better results by compensating for the weaknesses of each individual approach alone, as the *fundamental principle of mixed research*. In fact, Johnson and Onwuegbuzie (2004) insisted that it is time “methodologies catch up with practicing researcher” (p. 22) in emphasizing the need for more educational mixed methods studies. Too often, PD evaluation is relegated to pre- and post-PD quantitative surveys, but to discern deeper meaning, it important to get the voices of the educators who are experiencing the PD (Soliday, 2015). Qualitatively research allows a “deeper and more genuine expressions of beliefs and values that emerge through dialogue [and] foster[s] a more accurate description of views held” (Howe, 2004, p. 54).

As indicated by Webster-Wright (2009), it is of the utmost importance to incorporate both quantitative and qualitative experiences to understand how adults learn, noting that new insight was discovered,

...when we listen[ed] to professionals describing how they learn. Listening to descriptions of experiences of learning is different, incidentally, from asking professionals to choose which PD activities they find most useful, as often occurs when attempts are made to engage professionals in PD research. (p. 724)

The following sections will describe the research-based rubrics used to select STEM PD for FY17 and the participants in this study. The next section will look at the proposed mixed methods data collection procedures intended to answer the research questions and the proposed data analysis to be use to answer those questions. This mixed methods approach will allow the use of induction to discover patterns, the use of deduction to test hypotheses and ultimately, the use of abduction to attempt to determine the best explanation for the results (Johnson & Onwuegbuzie, 2004).

#### Research-Based Tools – Change the Equation™, STEMworks Rubric and Idaho-Specific Rubric

In order to meet the requirement of supporting ‘high quality STEM PD’, STEM AC determined that a systematic, transparent tool was needed to ensure that opportunities were fairly and objectively selected with input from Idaho’s experienced PD community including K12 educators, higher education professors, and experienced industry professionals. Using the research described in Chapter 2, STEM AC focused on the major characteristics of high quality PD including:

- 1) Increasing educator content knowledge;
- 2) Applications of that knowledge;
- 3) Educator reflection and collaborations;
- 4) Sustained and in-depth opportunities;
- 5) Student activities and outcomes.

In order to define the opportunity as high quality *STEM* PD, the focus must be STEM-based, defined previously as two (or more) integrated STEM disciplines.

With high quality PD defined as possessing the characteristics above, it was necessary to next develop or select a tool for vetting potential PD opportunities for Idaho educators. Change the Equation™ (CTEq) was formed in 2010, as a non-profit, non-partisan group consisting of over 100 U.S. CEOs. CTEq’s mission is to improve STEM learning for every child. To do this, they connect “business and education to ensure that all students are STEM literate by collaborating with schools, communities, and states to adopt and implement excellent STEM policies and programs” ([changetheequation.org](http://changetheequation.org)). CTEq had also developed an extensive, well-rounded, thoroughly vetted set of STEM resources housed in a database referred to as CTEq’s STEMworks ([changetheequation.org/stemworks](http://changetheequation.org/stemworks)). Based on the quality of the resources in the database, STEM AC’s Board determined that this would be an affordable alternative to requesting STEM AC staff develop a unique tool and platform which would have led to additional cost and increased time for the project to launch. As this effort began to take shape, the project was renamed STEM AC’s PD Initiative.

Because CTEq possessed a similar philosophy of connecting business and education, STEM AC began conversations related to the CTEq STEMworks rubric and database of resources. However, STEM AC did not simply want to adopt CTEq’s vetted resources without allowing Idaho PD experts to review the resources. Allowing Idaho PD experts to review every application would ensure that Idahoans had complete control over the final selected PD opportunities. In addition, this would mean that only those vendors and universities who wanted to engage with Idaho would apply for the PD Initiative.

With guarantees that Idahoans would review all applications, STEM AC began working with CTEq to develop the online platform to accept proposals. Consistent with the philosophies of both STEM AC and CTEq, the STEMworks rubric measures the levels to which proposals speak to a variety of areas including: need; evaluation; sustainability; replication/scalability; partnerships;

capacity; challenging and relevant content; STEM practices; inspiration; and underrepresented groups (see Appendix C: CTEq Rubric). Because all these measures are critical aspects of successful PD, STEM AC determined the CTEq rubric met the research-based criteria by which high quality STEM PD would be selected for Idaho educators during FY17.

However, STEM AC felt it needed additional information that was specific to Idaho. Therefore, in addition to the CTEq STEMworks rubric, an additional Idaho-specific rubric was developed by a team of university and K12 PD educators to meet the particular needs of Idaho educators and will also be required for the PD proposals (see Appendix D: Idaho-specific Questions). This additional information requires that the PD opportunities are truly integrated as this is STEM AC's adopted definition of STEM. Because of Idaho's unique geography and demographic distribution, it was also determined there was a need for supplementary information to ensure the PD would be viable throughout Idaho. Given the rural nature of the state and the uniquely distributed populations, it was imperative that PD proposals focus on the potential of serving the state broadly, not just in the urban epicenters; therefore, replicability and sustainability throughout Idaho were deemed to be important considerations for the PD Initiative applicants to be supported by STEM AC. Demonstrating that the PD would assist educators who work with Idaho's traditionally underrepresented populations in STEM is another important aspect STEM AC will consider in the evaluation process. Consistent with the literature cited in this research, STEM AC defined traditionally underrepresented populations to include females, rural Idaho communities, racial/ethnic minorities (primarily Hispanic populations), and students with low socio-economic status. Supporting educators in gaining tools to support these populations is important to increase the number and diversity of students continuing in a STEM pathway.

### Participants

STEM AC has defined an educator to be a formal PK-20 public educator as well as an informal (non-profit) educator, including a librarian, a school or career counselor, or even an adult mentor. Certain PD opportunities will allow STEM AC to focus on the broad definition of an educator while others will require STEM AC to narrow the definition to include only certified, formal K12 public education teachers. For this research, participants are currently practicing, certified, K12 Idaho public school teachers who will participate in one or more of the following: an anonymous educator PD survey; a PD focus group; or a STEM AC 'high quality PD' opportunity that will require they complete a pre- and post-PD survey.

### **Data Collection**

Theoretically, both research-based rubrics are sound; however, the purpose of this research is to ascertain the practical efficacy of the rubrics to select high quality PD as perceived by Idaho educators. With Idaho's vast geographic distribution and diverse population, Idaho educators need to be given the opportunity to assess the PD as well as to improve upon the research-based rubrics for the selection of future opportunities. Therefore, in FY17, educator PD will be selected based solely on the research-based rubrics (Appendices C and D). The opportunities that are selected from these rubrics will then be thoroughly evaluated by Idaho educators who participate in the PD. Educators will provide extensive feedback (both quantitative and qualitative) on the PD to ensure that the opportunity met their needs and evaluate if it was deemed to be of high quality. In addition to feedback on FY17 STEM PD opportunities, educators will also be asked to join focus groups where they will communicate with STEM AC about what they desired from STEM PD. This will be another way STEM AC can improve upon the research-based rubrics. In this fashion, selected opportunities will be evaluated and the research-based PD rubrics will be modified in subsequent years to reflect Idaho educator inputs.

In sum, the goals of this research are two-fold. First, to determine which opportunities are of the high quality according to educator surveys as these will then be offered and funded in subsequent years. The second goal is to determine if the research-based rubrics should be modified for future use in the selection of high quality PD opportunities for Idaho educators. The triangulation between the research-based rubrics, adult learning theory, and the data results will help STEM AC determine next steps in relation to future PD selection.

This research will be completed in two stages. Stage 1 is the pre-PD data collection. This will consist of a large group anonymous PD survey, two focus groups, and pre-PD surveys given prior to entering one of the research-based, rubric-selected opportunities. Stage 2 will be a through post-PD survey, culminating in asking educators if they viewed the opportunity as high, medium, or low quality.

#### Stage 1: Pre-PD Research

Anonymous surveys will be created to assess Idaho educators' perceptions of STEM PD in general and to define what they value in STEM PD experiences in order to determine if the CTEq and Idaho-specific research-based rubrics contain the PD elements that educators' value.

Approximately 200 participants will be surveyed at a statewide science and math conference in Boise, Idaho.

Figure 1 below illustrates the questions on the anonymous survey that are modelled after the two research-based rubrics (Appendices C and D). Of particular relevance are the terms that educators associate with high quality and low quality PD (questions 4 and 5). In addition, question 6 asks educators to rank order the most to least important terms associated with STEM PD and is directly related to the research-based rubrics.

### **Anonymous STEM Educator PD Survey and Focus Group Discussion Tool**

- 1) How many years have you been teaching?
- 2) Which subject areas do you currently teach? Please select all that apply.
- 3) On average, how many hours are your typical professional development experiences (STEM-related and otherwise)?
- 4) What are 3-5 words you would associate with '*high quality professional development*'?
- 5) What are 3-5 words would you associate with '*low quality professional development*'?
- 6) Please rank the following in order from most important to least important when experiencing professional development. Please use the scale from 1 (most important aspect of PD) to 9 (least important aspect of PD). Words below are listed alphabetically.
  - a. \_\_\_\_\_ Connects two or more disciplines, interdisciplinary (i.e. math and science)
  - b. \_\_\_\_\_ Contains challenging and relevant content
  - c. \_\_\_\_\_ Fosters partnerships with others (i.e. educators/industry/higher ed/organizations)
  - d. \_\_\_\_\_ Learn how to engage diverse learners
  - e. \_\_\_\_\_ Learn new best practices in STEM
  - f. \_\_\_\_\_ Meets my professional needs
  - g. \_\_\_\_\_ PD takes place over several sessions (sustainability)
  - h. \_\_\_\_\_ Provides readily usable resources
  - i. \_\_\_\_\_ Teaches me how to share my knowledge with students

### **Figure 1. Anonymous STEM Educator PD Survey and Focus Group Discussion Tool**

Data from qualitative questions 4 and 5 focusing on terms associated with high and low quality PD will be coded and analyzed for themes using the coding methodology of Saldaña (2009). Since question 6 is asking for ranked data, it is assumed that the data will be non-parametric. Therefore, it will be necessary to run a Friedman test instead of a one-way ANOVA. The Friedman test is often used for ordinal data or continuous data that has violated the assumption of normality (Zar, 2009). For the Friedman Test, the null hypothesis is: There is no difference in the respondents' ranks. The alternative hypothesis is: There is a difference in the respondents' ranks. If the null hypothesis is rejected, post hoc tests need to be performed using the Nemenyi method (1963). All

tests will be run in SPSS. Numerous studies support the Friedman test and post hoc Nemenyi method as a valid method for analyzing non-parametric, ranked data (Demšar, 2006; McCrum-Gardner, 2007; Zar, 2009) although others claim parametric tests are robust enough to tolerate violations like normality even using ranked data (Coe, 2002; Jamieson, 2004; Norman, 2010).

In addition to the anonymous surveys, focus groups will be conducted at the same conference to discuss specific questions from the anonymous survey. Two focus groups of 8-10 educators will take the same survey as the anonymous group, but will then discuss certain questions in depth to provide a deeper understanding of the survey responses (Appendix E: Focus Group Procedures and Questions). The focus groups will begin by discussing questions four and five related to terms educators associate with high and low quality PD. Then the group leader will transition into the rankings associated with question six as related to the research-based rubrics. The focus groups will discuss their individual rankings and the importance of each factor identified from the research-based rubrics. The group leader will steer the discussion to focus on what was the most important characteristic and why in an effort to gain a deeper understanding of the rankings.

Focus groups will follow the suggestions of Roulton (2010) and Marshall and Rossman (2016) in terms of preparing for the focus group, gaining consent, recruitment, and hosting the group as well as questioning techniques. Each group will be recorded and then transcribed. The transcribed recording will undergo initial coding using structural and descriptive coding techniques as described by Saldaña (2009) and DeCuir-Gunby, Marshall and McCulloch (2011). Once primary codes are determined, secondary coding techniques will involve focused coding (Saldaña, 2009) once themes have been identified via the primary coding techniques.

Desimone's research (2009) indicated that when teachers are asked to report on concrete PD experiences, surveys can elicit reliable information. In addition, her research also points to the validity of interviews and focus groups for collecting social self-report data. Therefore, data from

these focus groups will be analyzed concurrently with the aggregate quantitative responses from the anonymous survey data. Together, this information will guide STEM AC in understanding the most important features of PD based on Idaho STEM educator inputs. This information will also serve as a guide for perhaps modifying the weightings of the factors in the research-based rubrics and/or the addition or removal of categories in the rubrics for future use in the selection of STEM PD.

In addition to anonymous surveys and focus groups, a survey of pre-PD opinions and experiences will be required for educators who participate in the PD opportunities that were selected via the research-based rubrics. Using past STEM AC PD experiences, educator interest has surpassed the number of seats in the PD opportunity; therefore, it is anticipated there will be competitive selection of educators who participate in each opportunity. Participants in the opportunities will be selected based on criteria including interest, need, geographic location, and populations served, among others. Based on current STEM AC funding levels, it is anticipated that four PD opportunities will be funded at approximately \$100,000 per opportunity. If the opportunity is determined to be of high quality as defined by the Idaho participants, it will be possible to continue the PD for up to three additional years at approximately \$50,000 per year, assuming appropriate legislative funding. Therefore, educator surveys are an important factor in the selection and continuation of future STEM PD opportunities.

Appendix F contains the pre-PD questionnaire. Question 1 asks for the participant to read and electronically sign the informed consent form prior to proceeding through the questionnaire. Questions 2 – 18 are identical to the anonymous and focus group surveys although the format has been modified to meet the constraints of the Salesforce survey application. Therefore, these responses will be merged with the anonymous survey data file. In addition, a number of Knowles'-based adult learning theory questions have been added to determine if these assumptions are viable

as related to Idaho STEM educators. These questions focus on learner preference, motivation, background experiences, relevance, problem-centered activities, and reason for the learning.

If Knowles' assumptions regarding adult learning are true, then educators should strongly agree or agree with the majority of the statements in this section of the survey. Pre-PD surveys from all four selected opportunities will be merged and analyzed collectively since the survey is the same for all four opportunities and no STEM AC PD has yet occurred. It is anticipated there will be 20 educators per opportunity. Individual responses from questions 19 – 25 will be coded from 1 (strongly disagree) to 6 (strongly agree) using a Likert scale. Then characteristic scores will be averaged. As with the rank order portion of this research, it is assumed normality will be violated; therefore, using SPSS to analyze the data with the Friedman test and post hoc Nemenyi method will determine which factor(s), if any, have a significantly higher ranking than other factors. It is assumed that the factors will not differ significantly from one another and that all factors will receive high (agree, strongly agree) rankings if Knowles' assumptions of adult learners are true of Idaho STEM educators. Conclusion will be drawn on the characteristic(s), if any, which hold the most importance.

### Stage 2: Post-PD Research

The post-PD survey (Appendix G) has questions derived from three sources: Darling-Hammond and Richardson (2009); Smith and Gillspie (2007); and the Iowa Governor's STEM Advisory Council's 2015-2016 Evaluation Report. The Darling-Hammond and Richardson (2009) questions focus on increasing educator knowledge of the content, how students learn the content, delivery format of the PD to the educator, and time for educator collaboration. The Smith and Gillespie (2007) questions focus on relevance to current teaching assignment, overcoming barriers to implementation, increasing content knowledge, and delivery format of the PD.

The Iowa Governor's STEM Advisory Council also uses CTEq STEMworks model to select PD and curriculum for six regions throughout Iowa. Each of the six regions is linked to a regional university or community college. Because Iowa is in their third year of implementation using the STEMworks model, they have a number of evaluation reports available online ([iowastem.gov/sites/default/files/evaluation/2015-16-Iowa-STEM-Evaluation-Report.pdf](http://iowastem.gov/sites/default/files/evaluation/2015-16-Iowa-STEM-Evaluation-Report.pdf)). Based on the similarities between the Idaho and Iowa methodologies, a number of questions from the Iowa PD survey will be used for Idaho educators focusing specifically on educator confidence, knowledge, effective teaching, student questioning, diverse learners, integration, and administrative support. Questions from this post-PD survey section will be rated on a Likert scale of 1 – 6 using the terms ranging from strongly disagree (coded as 1) to strongly agree (coded as 6).

The remaining questions are extended response questions related to challenges and successes, needed and expected supports, as well as knowledge gained and expected student interactions. The survey concludes by asking if other educators would benefit from this opportunity, if the PD should be offered in subsequent years and if the PD was ranked as high (medium or low) quality.

All pre- and post-surveys will be administered online using Salesforce and the Community Grant Portal (CGP) application. STEM AC now only accepts competitive PD and grant applications through CGP, requiring educators create a password-protected login. CGP also allows tracking of funded applications as well as completion of activities, final reports, and uploading of aggregate student data outcomes, surveys, and photos. Since most PD opportunities are competitive, CGP also allows Idaho reviewers to access the system, review applications, and upload comments allowing applicants to view reviewers' scores and comments on the secure platform. Ensuring that all data is consolidated into a single platform allows for ease of access, tracking, and ensuring compliance with the parameters of the grant or PD. Although the survey system is not as robust as other programs, it allows for applicant data to be permanently linked to their file. It also ensures that all applicants

complete the surveys and pre- and post-PD questions can be streamlined to eliminate redundancy. Responses will be aggregated and exported into Excel for any data coding and cleaning prior to import into SPSS. Once exported from CGP, responses will be stripped of any personally identifiable information prior to file manipulation.

This study is not designed as a repeated measures study; therefore, pre-PD and post-PD questions are not linked other than years teaching, grade, and content area. This study is not attempting to measure changes in attitudes and/or content knowledge as that is beyond the scope of this work. Pre-PD and post-PD surveys serve two distinct purposes. Pre-PD surveys are focused on determining if Knowles' assumptions of adult learners are accurate for Idaho STEM educators. Post-PD surveys have the primary goal of identifying if the opportunity is of high quality and secondarily, the characteristics that are correlated with high quality opportunities. Variable such as attitudinal changes, practices, and student outcomes should certainly be measured, but are beyond this scope of work.

After an exhaustive search, no clear cut-offs appear to exist in the research related to a high quality PD experience. Just how many participants need to agree that the opportunity is of high quality to classify it as such? Does one person defining the opportunity as low quality equate to the entire opportunity being eliminated from a high quality option? The preliminary working assumptions will be that opportunities will be deemed to be of high quality if they meet the following criteria: 1) No participants ranked the PD as low quality and 2) At least 70% of the participants ranked the PD as high quality. If additional metrics are discovered, then it will be possible to adjust these values accordingly.

For PD that is determined to be of high quality, SPSS will be used to correlate responses and to evaluate the total impact of the PD opportunity. It is likely that a statistician will need to be involved to support the multivariate correlations that will be required, especially if the assumptions

of normality, linearity and/or homoscedasticity are violated and non-parametric measures are required. The multivariate correlation method for ranked, non-parametric data is most commonly Kendall's coefficient of concordance (Bishara & Hittner, 2012; Legendre, 2010; Zar, 2009). Because the focus is on the variable rankings that are highly correlated with high quality PD, this might best be accomplished using a top-down concordance and analysis of the Savage scores (Iman & Conover, 1987; Teles, 2012).

Ideally, assuming enough participants, each opportunity determined to be of high quality would be analyzed individually to determine the most important characteristics associated with that particular PD. However, comparability between the opportunities is not the focus of this research. As noted previously, these opportunities span various grade and content levels and as a result, target a different group of educators. If the opportunity is deemed to be of high quality, the comparison between the groups is irrelevant because it is of no consequence to this study if one high quality opportunity ranks higher than another high quality opportunity. Rather, the goal is to determine characteristics of opportunities that, when taken together, determine the most important factor(s) associated with high quality STEM PD. Therefore, the data sets will be merged for those opportunities that were determined to be high quality to identify which variables were most highly correlated with the entire high quality PD experience.

Consistent with other coding methods used in this paper and throughout the research, the works of Saldaña (2009) and DeCuir-Gunby, et al. (2011) will be used to guide the primary and secondary qualitative coding techniques which will derive main themes for each of the extended response answers. Pertinent quotes and insights will be used directly as outcomes evidence.

### **Conclusion**

By understanding educator needs in high quality STEM PD in a systematic fashion and then evaluating the PD opportunities that are selected, it will be possible to determine if the CTEq and the

Idaho-specific rubrics need to be modified or if the two rubrics, taken together, are effective tools for selecting high quality educator STEM PD without additional modifications. Group surveys and educator focus groups will be used to determine if research-based rubrics encompass the desired PD characteristics for Idaho educators. Pre- and post-PD survey data will be used to correlate the most important variables associated with adult learning and high quality STEM PD. Inferences will be drawn from both the qualitative and quantitative analyses to determine if adjustments should be made to the two research-based rubrics prior to their utilization in the selection of future PD opportunities.

As stated by Desimone (2009), “having a core set of characteristics that we know are related to effective professional development, and measuring them every time we study professional development, would help move the field forward” (p. 186). This study is an attempt to determine which factors not only should be used to select future STEM PD opportunities, but also to then measure those opportunities in a consistent way so that comparisons can be made over time regarding the effectiveness of STEM PD opportunities. In this fashion, the research on teacher learning through STEM PD would support adaptation and customization (Fishman & Krajcik, 2003) while maintaining a consistent base of qualitative and quantitative questions and analyses.

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## APPENDIX A

### STEM Occupations by Subdomain (Idaho Department of Labor, 2015)

Key	Sub-domain	
	1	Life and Physical Science, Engineering, Mathematics, and Information Technology Occupations
	2	Social Science Occupations
	3	Architecture Occupations
	4	Health Occupations
		Split across 2 sub-domains
	Types of occupations	
	A	Research, Development, Design, or Practitioner Occupations
	B	Technologist and Technician Occupations
	C	Postsecondary Teaching Occupations
	D	Managerial Occupations
	E	Sales Occupations
Sub-domain and Type of Occupation	2010 SOC code	2010 SOC title
1.A	15-1111	Computer and Information Research Scientists
1.A	15-1121	Computer Systems Analysts
1.A	15-1122	Information Security Analysts
1.A	15-1132	Software Developers, Applications
1.A	15-1133	Software Developers, Systems Software
1.A	15-1134	Web Developers
1.A	15-1141	Database Administrators
1.A	15-1142	Network and Computer Systems Administrators
1.A	15-1143	Computer Network Architects
1.A	15-1199	Computer Occupations, All Other

1.A	15-2011	Actuaries
1.A	15-2021	Mathematicians
1.A	15-2031	Operations Research Analysts
1.A	15-2041	Statisticians
1.A	15-2099	Mathematical Science Occupations, All Other
1.A	17-2011	Aerospace Engineers
1.A	17-2021	Agricultural Engineers
1.A	17-2031	Biomedical Engineers
1.A	17-2041	Chemical Engineers
1.A	17-2051	Civil Engineers
1.A	17-2061	Computer Hardware Engineers
1.A	17-2071	Electrical Engineers
1.A	17-2072	Electronics Engineers, Except Computer
1.A	17-2081	Environmental Engineers
1.A	17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors
1.A	17-2112	Industrial Engineers
1.A	17-2121	Marine Engineers and Naval Architects
1.A	17-2131	Materials Engineers
1.A	17-2141	Mechanical Engineers
1.A	17-2151	Mining and Geological Engineers, Including Mining Safety Engineers
1.A	17-2161	Nuclear Engineers
1.A	17-2171	Petroleum Engineers
1.A	17-2199	Engineers, All Other
1.A	19-1011	Animal Scientists
1.A	19-1012	Food Scientists and Technologists
1.A	19-1013	Soil and Plant Scientists
1.A	19-1021	Biochemists and Biophysicists
1.A	19-1022	Microbiologists
1.A	19-1023	Zoologists and Wildlife Biologists
1.A	19-1029	Biological Scientists, All Other

1.A	19-1031	Conservation Scientists
1.A	19-1032	Foresters
1.A	19-1041	Epidemiologists
1.A	19-1042	Medical Scientists, Except Epidemiologists
1.A	19-1099	Life Scientists, All Other
1.A	19-2011	Astronomers
1.A	19-2012	Physicists
1.A	19-2021	Atmospheric and Space Scientists
1.A	19-2031	Chemists
1.A	19-2032	Materials Scientists
1.A	19-2041	Environmental Scientists and Specialists, Including Health
1.A	19-2042	Geoscientists, Except Hydrologists and Geographers
1.A	19-2043	Hydrologists
1.A	19-2099	Physical Scientists, All Other
1.B	15-1131	Computer Programmers
1.B	15-1151	Computer User Support Specialists
1.B	15-1152	Computer Network Support Specialists
1.B	15-2091	Mathematical Technicians
1.B	17-1021	Cartographers and Photogrammetrists
1.B	17-1022	Surveyors
1.B	17-3012	Electrical and Electronics Drafters
1.B	17-3013	Mechanical Drafters
1.B	17-3019	Drafters, All Other
1.B	17-3021	Aerospace Engineering and Operations Technicians
1.B	17-3022	Civil Engineering Technicians
1.B	17-3023	Electrical and Electronics Engineering Technicians
1.B	17-3024	Electro-Mechanical Technicians
1.B	17-3025	Environmental Engineering Technicians
1.B	17-3026	Industrial Engineering Technicians
1.B	17-3027	Mechanical Engineering Technicians

1.B	17-3029	Engineering Technicians, Except Drafters, All Other
1.B	17-3031	Surveying and Mapping Technicians
1.B	19-4011	Agricultural and Food Science Technicians
1.B	19-4021	Biological Technicians
1.B	19-4031	Chemical Technicians
1.B	19-4041	Geological and Petroleum Technicians
1.B	19-4051	Nuclear Technicians
1.B	19-4091	Environmental Science and Protection Technicians, Including Health
1.B	19-4092	Forensic Science Technicians
1.B	19-4093	Forest and Conservation Technicians
1.B and 2.B	19-4099	Life, Physical, and Social Science Technicians, All Other
1.B and 3.B	17-3011	Architectural and Civil Drafters
1.C	25-1021	Computer Science Teachers, Postsecondary
1.C	25-1022	Mathematical Science Teachers, Postsecondary
1.C	25-1032	Engineering Teachers, Postsecondary
1.C	25-1041	Agricultural Sciences Teachers, Postsecondary
1.C	25-1042	Biological Science Teachers, Postsecondary
1.C	25-1043	Forestry and Conservation Science Teachers, Postsecondary
1.C	25-1051	Atmospheric, Earth, Marine, and Space Sciences Teachers, Postsecondary
1.C	25-1052	Chemistry Teachers, Postsecondary
1.C	25-1053	Environmental Science Teachers, Postsecondary
1.C	25-1054	Physics Teachers, Postsecondary
1.D	11-3021	Computer and Information Systems Managers
1.D	11-9121	Natural Sciences Managers
1.D and 3.D	11-9041	Architectural and Engineering Managers
1.E	41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products
1.E	41-9031	Sales Engineers
2.A	19-3011	Economists
2.A	19-3022	Survey Researchers
2.A	19-3031	Clinical, Counseling, and School Psychologists

2.A	19-3032	Industrial-Organizational Psychologists
2.A	19-3039	Psychologists, All Other
2.A	19-3041	Sociologists
2.A	19-3051	Urban and Regional Planners
2.A	19-3091	Anthropologists and Archeologists
2.A	19-3092	Geographers
2.A	19-3094	Political Scientists
2.A	19-3099	Social Scientists and Related Workers, All Other
2.B	19-4061	Social Science Research Assistants
2.C	25-1061	Anthropology and Archeology Teachers, Postsecondary
2.C	25-1062	Area, Ethnic, and Cultural Studies Teachers, Postsecondary
2.C	25-1063	Economics Teachers, Postsecondary
2.C	25-1064	Geography Teachers, Postsecondary
2.C	25-1065	Political Science Teachers, Postsecondary
2.C	25-1066	Psychology Teachers, Postsecondary
2.C	25-1067	Sociology Teachers, Postsecondary
2.C	25-1069	Social Sciences Teachers, Postsecondary, All Other
3.A	17-1011	Architects, Except Landscape and Naval
3.A	17-1012	Landscape Architects
3.C	25-1031	Architecture Teachers, Postsecondary
4.A	29-1011	Chiropractors
4.A	29-1021	Dentists, General
4.A	29-1022	Oral and Maxillofacial Surgeons
4.A	29-1023	Orthodontists
4.A	29-1024	Prosthodontists
4.A	29-1029	Dentists, All Other Specialists
4.A	29-1031	Dietitians and Nutritionists
4.A	29-1041	Optometrists
4.A	29-1051	Pharmacists
4.A	29-1061	Anesthesiologists

4.A	29-1062	Family and General Practitioners
4.A	29-1063	Internists, General
4.A	29-1064	Obstetricians and Gynecologists
4.A	29-1065	Pediatricians, General
4.A	29-1066	Psychiatrists
4.A	29-1067	Surgeons
4.A	29-1069	Physicians and Surgeons, All Other
4.A	29-1071	Physician Assistants
4.A	29-1081	Podiatrists
4.A	29-1122	Occupational Therapists
4.A	29-1123	Physical Therapists
4.A	29-1124	Radiation Therapists
4.A	29-1125	Recreational Therapists
4.A	29-1126	Respiratory Therapists
4.A	29-1127	Speech-Language Pathologists
4.A	29-1128	Exercise Physiologists
4.A	29-1129	Therapists, All Other
4.A	29-1131	Veterinarians
4.A	29-1141	Registered Nurses
4.A	29-1151	Nurse Anesthetists
4.A	29-1161	Nurse Midwives
4.A	29-1171	Nurse Practitioners
4.A	29-1181	Audiologists
4.A	29-1199	Health Diagnosing and Treating Practitioners, All Other
4.B	29-2011	Medical and Clinical Laboratory Technologists
4.B	29-2012	Medical and Clinical Laboratory Technicians
4.B	29-2021	Dental Hygienists
4.B	29-2031	Cardiovascular Technologists and Technicians
4.B	29-2032	Diagnostic Medical Sonographers
4.B	29-2033	Nuclear Medicine Technologists

4.B	29-2034	Radiologic Technologists
4.B	29-2035	Magnetic Resonance Imaging Technologists
4.B	29-2041	Emergency Medical Technicians and Paramedics
4.B	29-2051	Dietetic Technicians
4.B	29-2052	Pharmacy Technicians
4.B	29-2053	Psychiatric Technicians
4.B	29-2054	Respiratory Therapy Technicians
4.B	29-2055	Surgical Technologists
4.B	29-2056	Veterinary Technologists and Technicians
4.B	29-2057	Ophthalmic Medical Technicians
4.B	29-2061	Licensed Practical and Licensed Vocational Nurses
4.B	29-2071	Medical Records and Health Information Technicians
4.B	29-2081	Opticians, Dispensing
4.B	29-2091	Orthotists and Prosthetists
4.B	29-2092	Hearing Aid Specialists
4.B	29-2099	Health Technologists and Technicians, All Other
4.B	29-9011	Occupational Health and Safety Specialists
4.B	29-9012	Occupational Health and Safety Technicians
4.B	29-9091	Athletic Trainers
4.B	29-9092	Genetic Counselors
4.B	29-9099	Healthcare Practitioners and Technical Workers, All Other
4.C	25-1071	Health Specialties Teachers, Postsecondary
4.C	25-1072	Nursing Instructors and Teachers, Postsecondary
4.D	11-9111	Medical and Health Services Managers

## APPENDIX B

### Idaho STEM Action Center Strategic Plan

#### Idaho STEM Action Center

#### 2017 – 2020 Strategic Plan

##### **Introduction, History and Future**

Idaho is facing a crisis: Idaho citizens are not entering the STEM pipeline at a rate that will meet the current and future workforce needs of Idaho employers and sustain Idaho's economic development and future prosperity. According to a report by the Idaho Department of Labor, by 2025 Idaho will be lacking approximately 63,000 individuals needed to fill projected positions ranging from construction and service jobs to medical and technology positions, many of which involve STEM-related skills and knowledge. Numerous research studies including the Georgetown Center for Education and the Workforce, Idaho Business for Education and Idaho Department of Labor demonstrate that more than 60% of the projected jobs by 2020 will require a college degree or certificate beyond a high school diploma.

During the 2015 Idaho legislative session, a small group of visionary legislators, education leaders and industry stakeholders began a STEM Caucus that led to legislation creating the Idaho STEM Action Center. House Bill 302 became law on July 1, 2015 (Idaho Code §67-823). This new law permits some flexibility in implementation which will allow the Center to develop unique grant, training, professional development and student opportunities aligned to Idaho's workforce needs from kindergarten through career. Decisions related to the STEM Action Center are guided by a nine member Board appointed by the Governor. The Board is a unique blend of educational leaders from the State Board of Education and the State Department and seven Idaho industry leaders including the Idaho Department of Labor, the Idaho Department of Commerce, Idaho National Laboratory (INL) and Micron.

The Idaho STEM Action Center's enabling legislation focuses on five broad areas: a) student learning and achievement (including underrepresented populations); b) student access to STEM including equity issues; c) teacher professional development and opportunities; d) college and career STEM pathways; and e) industry and workforce needs.

During the 2016 legislative session, two pieces of legislation were passed that focused on a statewide computer science initiative. The STEM Education Fund was created through Senate Bill 1279 into which two million dollars was deposited from the state's general fund to support the computer science initiative (House Bill 379). The legislative intent of the computer science initiative is to increase statewide efforts in computer science awareness and access, kindergarten through career. These efforts will continue to be driven by the needs of Idaho's industry and developed in partnership with industry, the state board of education, professional-technical education, the state department of education, administrators, educators and the community at large. The ultimate goal is to secure industry participation in the funding of the state's computer science education initiatives.

The Idaho STEM Action Center supports the recommendations of the Idaho Task Force for Improving Education and the State Board of Education's STEM Strategic Plan, which support the state's 60% goal and seeks to meet the workforce needs of Idaho business and industry.

As a result of these statewide efforts, Idaho will become a STEM business destination. Idaho will have a citizenry that not only recognizes the importance of STEM, but also possesses the necessary STEM skills for the workforce. A highly skilled STEM workforce will lead to increased investment and business opportunities throughout Idaho. Educators will have the necessary STEM skills to engage students. Students will possess the 21<sup>st</sup> century skills that employers require: critical thinking, problem-solving, collaboration and innovation. The result of this multi-tiered approach will be an increase in the number of businesses in Idaho and the number of STEM jobs available for Idahoans which will serve to bolster Idaho's economy and lead to long-term economic prosperity for the state and her citizens.

**Mission Statement:**

Connecting STEM education and industry to ensure Idaho's long-term economic prosperity.

**Vision Statement:**

Produce a STEM competitive workforce by implementing Idaho's Kindergarten through Career STEM education programs aligned with industry needs.

**GOAL #1: Coordinate and facilitate implementation of STEM programs throughout Idaho**

**Objective 1A:** Create/identify and fund STEM opportunities for Idaho students

Performance Measure 1: Number of students receiving services from the STEM Action Center

*-Baseline 1:* During FY16, 10,428 students received services from the STEM Action Center, primarily through grants disseminated to educators and/or adult mentors

*-Benchmark 1:* Increase the number of student served annually until at least 25,000 students are served throughout Idaho each year

*How was this benchmark established?* 25,000 students represent nearly 10% of the K12 populations which would be served annual by the Center. Given the current number of staff, this is the maximum number that the Center can serve effectively.

**Objective 1B:** Identify and facilitate delivery of high quality STEM educator professional development

Performance Measure 1: Number of educators receiving high quality STEM professional development

*-Baseline 1:* Four opportunities impacting 1,200 educators were offered in FY16

-*Benchmark 1:* Increase the number of opportunities by at least one each year until 10 opportunities are reached

-*Benchmark 2:* Continue to expand opportunities until at least 5,000 educators are reached annually

*How were these benchmark established?* Four opportunities were offered by the Center staff in FY16. With the addition of another staff member, contractors and an increased appropriation, ten opportunities (serving 5,000 educators) would be the maximum number to ensure that educators receive the highest quality STEM professional development as directed in Idaho Code §67-823

**Objective 1C:** Develop new and expand existing STEM Action Center grant programs for educators and the community at large

Performance Measure 1: Total number of grants distributed

-*Baseline 1:* Two grant opportunities for educators and one for students were made available in FY16

-*Benchmark 1:* Increase the existing opportunities to at least five including computer science opportunities for educators and at least two opportunities for students

*How was this benchmark established?* Given the current level of Center staffing, seven grant opportunities are the maximum number that can be managed annually and effectively.

Performance Measure 2: Percentage of applicants receiving funding

-*Baseline 1:* 22% of educator requests were filled for the PK12 grant in FY 16.

-*Benchmark 1:* Fill at least 30% of the PK12 grant requests by FY20

*How was this benchmark established?* The number of grant requests will likely continue to increase and the need for additional support will be required to fill the requests. 30% will allow for a competitive process and will ensure that applications are thoughtful and through with measurable outcomes and evident need.

**Objective 1D:** Support the [Idaho State Board of Education STEM Strategic Plan](#)

**GOAL #2: Align education and workforce needs throughout Idaho**

**Objective 2A:** Engage industry to support STEM education outcomes

Performance Measure 1: Number and amount of industry contributions and personal donations to Center to promote and enhance opportunities for K-career

*Baseline 1:* \$62,000 in industry contributions and \$10,000 in personal donations to the Center in FY16 = \$72,000

*Benchmark 1:* Increase industry contribution each fiscal year until \$500,000 is reached annually

*Benchmark 2:* Hold additional fundraisers to double personal donations by FY20 by advertising the Idaho income tax credit option

*How were these benchmark established?* If the contributions to the Center double annually, this benchmark can be reached. As the Center becomes more established, industry will become more familiar with Center projects and programs. As a result, partnerships are anticipated to grow and donations will increase.

**Objective 2B:** Involve industry to collaborate with the STEM Action Center and focus outcomes and goals on workforce needs and opportunities

-Performance Measure 1: Number of opportunities for workforce certifications in high demand fields

*Baseline 1:* The STEM Action Center currently does not support these types of certifications; a baseline will be established in FY17

*Benchmark 1:* Benchmark(s) will be set after the FY17 baseline data is collected and analyzed

Performance Measure 2: Number of trainings in STEM and/or computer science and number of computer science and/or STEM endorsement received

*-Baseline 1:* No efforts were deployed in FY16

*-Benchmark 1:* Benchmark(s) will be set after the FY17 baseline data is collected and analyzed

**Objective 2C:** Create opportunities for schools to partner with local companies to provide for student and teacher mentoring and internships in computer science and/or STEM.

Performance Measure 1: Number of mentors and students involved in the Center's virtual, project-based mentorship platform

*-Baseline 1:* No virtual mentorship project-based platform currently exists. In FY17 an RFP will be released and a vendor will be selected to design a platform

*-Benchmark 2:* Baseline user data will be collected in FY18 and user benchmarks will be established for FY19

Performance Measure 2: Number of industries and students involved in the Computer Science Coop Project

*-Baseline 1:* No Coop program currently exists in Idaho

*-Benchmark 1:* Baseline data will be collected in FY17 with a scaling plan in place for FY18 – FY20

**Objective 2D:** Support computer science initiatives, programs, events, training and other promotions throughout the state for the benefit of school districts, students, parents and local communities

Performance Measure 1: Number of community events related to computer science

*-Baseline 1:* No support was provided in FY16

*-Benchmark 1:* Benchmarks will be set after FY17 once baseline data is collected and analyzed

Performance Measure 2: Number of educator professional development opportunities in computer science

*-Baseline 1:* In FY16, the Center supported one opportunity involving 44 educators with \$8,000 in continuing education credits and training through Code.org

*-Benchmark 1:* By FY20 increase to at least three opportunities and support at least 150 educators

*How was this benchmark established?* Given the increase in the FY17 appropriation and the addition of staffing to the Center, it will be possible to support at least three opportunities annually and collect effective outcome data.

Performance Measure 3: Number of student competitions in computer science

*-Baseline 1:* Computer science student competitions were not supported by the Center in FY16

*-Benchmark 1:* Support at least two computer science competitions per year by FY20

*How was this benchmark established?* With the additional Center staffing, computer science competitions can be researched for implementation in Idaho. Currently, computer science competitions are not common and students are not abundant so two competitions would allow student choice while ensuring sufficient numbers of competitors.

### **GOAL #3: Increase awareness of STEM throughout Idaho**

**Objective 3A:** Collaborate with Idaho's state board of education, division of career-technical education, the state department of education, public higher education institutions and industry to develop a communication plan related to the computer science initiative and STEM

Performance Measure 1: Number of collaboratively created communication resources

*-Baseline 1*: No collaborative communication resources were created in FY16

*-Benchmark 1*: Benchmarks will be established after FY17 baseline data is collected

**Objective 3B**: Communicate about STEM and computer science initiatives, programs, events, training and other promotions throughout the state for the benefit of school districts, students, parents and local communities

Performance Measure 1: Number of users of the STEM Action Center online portal of resources and best practices

*-Baseline 1*: No online portal currently exists. Portal will be created in FY17 and deployed by FY18

*-Benchmark 1*: Benchmarks will be established after FY18 baseline data is collected

*-Benchmark 2*: Deploy online pilot database during FY18 which annually identifies at least five (5) best practice innovations used in Idaho schools that have resulted in growth in interest and performance in STEM and/or computer science by students and teachers

How was this benchmark established? This benchmark is required by Idaho Code §67-823.

Performance Measure 2: Number of industries involved in the STEM Matters Media Campaign

*-Baseline 1*: No media campaign currently exists

*-Benchmark 1*: Benchmarks will be established after FY17 baseline data is collected

Performance Measure 3: Number of monthly communication efforts using the monthly newsletter, website and social media such as Facebook

*-Baseline 1*: Four newsletters were sent in FY16, reaching 1,500 subscribers

*-Benchmark 1*: Increase the number of newsletter subscribers by at least 10 subscribers per month until 2,000 subscribers are reached

How was this benchmark established? All K12 principals and superintendents were automatically enrolled in the newsletter. Self-subscriptions occur at a slower rate of 10 on average per month.

**Objective 3C**: Increase access of students, educators and communities that represent traditionally underrepresented populations in STEM and computer science

Performance Measure 1: Number of grants and professional development opportunities which target traditionally underrepresented populations in STEM and/or computer science

*-Baseline 1*: Three grants and one professional development opportunity were provided to support traditionally underrepresented populations in STEM in FY16

*-Benchmark 1*: Support at least three grants and two professional development opportunities in both STEM and computer science by FY20 to support traditionally underrepresented populations including rural, socioeconomic status, race/ethnicity and gender.

How was this benchmark established? As dictated in Idaho Code §67-823, the Center must support grants and professional development for traditionally underrepresented populations. Given the current staffing and funding levels, supporting at least five opportunities would allow high quality customer service and ensure effective outcome measurements.

### **External Factors Affecting Goals**

#### 1) Infrastructure

- a. As a small agency of three full time individuals, infrastructure can significantly influence outcomes. Contractors will be hired to fulfill legislative intent for Center programs and projects which will lead to increase productivity for the Center. Additional staffing would help the Center meet its goals in a more timely fashion.
- b. The Center needs to continue to leverage existing resources to prevent duplication. This will require knowledge of activities occurring outside of the Center and clear, timely communication between numerous entities which could be challenging.

#### 2) Funding and Economic Conditions

- a. Funding will be needed in an ongoing capacity to fulfill the intent of both the STEM Action Center legislation and the Computer Science Initiative.
- b. Partnering with industry will require industry awareness and confidence in the Center as well as the financial confidence in the economy.
- c. Grant availability will also drive certain aspects of Center activity and may vary annually.

#### 3) Statewide Awareness

- a. In order to ensure statewide equity, it will be critical that the Center raise awareness of the availability of grants, professional development opportunities and scholarships. Increased communication efforts will be necessary to facilitate this awareness.
- b. When soliciting requests for proposals, the Center must assume that it will receive numerous applications that are within the proposed budgets.
- c. Unrecognized demand for STEM Action Center resources could lead to an increased need to reviewers/volunteers to determine recipients of project and program opportunities.
- d. When offering professional development and grant opportunities, messaging to ensure statewide interest and diversity will be paramount to guarantee educators and communities from diverse backgrounds are represented.

APPENDIX C

**Change the Equation STEM Works Design Principals Rubric**



# DESIGN PRINCIPLES



This rubric aims to help companies gauge the quality of their philanthropic efforts to boost learning in science, technology, engineering and mathematics (STEM). It was created by Change the Equation (CTEq), a national non-profit coalition of nearly 100 corporate CEOs who are committed to improving STEM learning for every child, with a particular focus on under-represented minorities in STEM. The rubric aligns with a set of common “*Design Principles for Effective STEM Philanthropy*” drafted by representatives of CTEq member companies.

Together, the Principles and Rubric aim to provide a framework for corporate engagement that measurably improves the STEM performance of our nation’s young people.

It can help you ask the right questions of partners or grantees and to give structure to your analysis of STEM learning programs. Because STEM learning programs vary greatly in their purpose or focus, many very worthy programs might not measure up on every point in the rubric. Still, it is important to pay careful attention to the whole rubric as you review your entire portfolio of investments in STEM learning. Companies whose efforts routinely fail to meet many of the Design Principles are not likely to contribute to solving one of our nation’s most pressing problems: Our young people’s lagging performance in ST

**NOTE:** The rubric has been designed to flow directly from Principles A and B. Programs must be able to clearly identify a need and target audience in Principle A and show evidence of impact in Principle B. Programs should then be able to address each of the remaining principles (C-J) by continually referring back to the need, the target audience, and any evidence of impact. In almost all cases, a program must be able to provide evidence and/or impact in order to be rated as Accomplished for any principle.

## A. Need: Does the program address a compelling and well-defined need?

### ACCOMPLISHED

Statement of need is clear, compelling, and supported by recent, valid, and targeted data.

Program makes clear that it adds unique value in addressing the need.

Target audiences are well defined and closely tied to statement of need.

Program can demonstrate that it is reaching the target audience.

### DEVELOPING

Statement of need is clear and compelling but cites only general data.

Program identifies other past or present programs that address the same need, but does not fully demonstrate how it adds to those programs.

Program defines target audiences but does not clearly tie them to statement of need.

Program makes clear efforts to reach target audience but cannot demonstrate what proportion of those audiences it is reaching.

### UNDEVELOPED

Description of need is vague or unconvincing and cites little or no data.

Program makes no attempt to identify or evaluate other past or present programs that address the same need.

Program does not make clear what audiences it is targeting.

Program makes little effort to reach intended audience.

#### Sample evidence:

- Program description
  - Literature review with cited, research-based data
  - Mission/vision or goal statement for program (includes the target population for the program)
  - Existing needs assessment data that was used for planning and/or program development
  - Logic model
  - Evaluation reports that define the need, the target audience, and/or recent data from the research base
  - Student/participant demographic data
  - Documents that reflect where the program fits into the landscape of existing efforts

## B. Evaluation: Does the program use rigorous evaluation to continuously measure and inform progress in addressing the compelling need identified in Principle A?

### ACCOMPLISHED

StatProgram goals are well-defined and linked directly to the statement of need and the identified target audience.

Current rigorous evaluation data demonstrate that the program is reaching its goals and having an impact with the target audience. If the program was established within the last three years, it is based on high quality research and has a plan for a rigorous evaluation.

Program regularly uses current data from external or internal evaluations to identify and act on opportunities for improvement. A viable timeline with clear milestones for measuring progress is included.

### DEVELOPING

StateProgram goals are well-defined and feasible but difficult to measure.

Program conducts its own evaluation in lieu of third-party evaluation. Program is based on research that does not directly apply to the program's circumstances.

Program only sporadically uses current evaluation data to identify and act on opportunities for improvement. A scope of work is included, but the timeline is vague or nonexistent.

### UNDEVELOPED

Goals are poorly defined—or too unambitious to be worthwhile.

There is no research cited or plan to evaluate the program's progress to meet goals.

Program has no plans for using current evaluation data to improve itself. The program lacks clear milestones or timeline.

#### Sample evidence:

- Documents reflecting scope of work with measurable goals, milestones, timeline
- Evaluation report/s that demonstrate the defined need is being met and/or the target population is being impacted. A rigorous evaluation report:
  - > Is conducted by a third-party evaluator
  - > Outlines clear program goals
  - > Describes the evaluation methodology
  - > Ties program goals to measurable impacts
  - > Includes copies of instruments and measures used
- Third-party evaluation reports of progress or plans to secure third-party evaluation (for newer programs)
- Pre-Post Assessments (i.e. student/participant data) addressing learning outcomes
- Interviews/Focus groups/surveys of participants and staff and/or case studies/cognitive labs of participants
- Internal evaluation reports of progress
- Documents reflecting changes in program based on formative use of evaluation data

## C. Sustainability: Does the program ensure that the work is sustainable?

### ACCOMPLISHED

Program has identified and made concrete plans to take advantage of opportunities such as matching funds, favorable state or local policies, or existing reform initiatives. Plans are clear for sustaining the program with public funds or ongoing support from other partners if/when philanthropic support ends.

Projected benefits to teaching and/or learning justify the cost per participant.

Program has identified potential challenges such as unstable political environments, changes in leadership, and bureaucratic barriers, and it has detailed plans in place to deal with such contingencies.

All stakeholder organizations actively support the program and communicate that support to their members or employees.

### DEVELOPING

Program has identified opportunities for securing future internal and external support after philanthropic support ends, but they are more hopeful than viable.

The cost per participant is high but justified, and there is a viable plan to reduce costs.

Program has identified potential challenges, but plans for addressing them are not yet fully developed.

Some stakeholders are supportive but there is no plan to communicate the importance of the program to others.

### UNDEVELOPED

Program has made no efforts to identify funding opportunities that could advance its work. There is no plan or commitment to ensure the program's long-term survival after philanthropic support ends.

The program cannot demonstrate a benefit that justifies the cost per participant.

Program makes no effort to address potential barriers to sustainability.

Critical stakeholders—such as school district or community leaders—are barely aware that the program exists.

#### Sample evidence:

- Documents reflecting on-going support from a funding source and/or no ongoing costs or leadership demands that cannot be sustained if funding is withdrawn
- Documents reflecting stakeholder organizations (i.e. school district; community group) actively support program efforts (and communicate that support to their members, employees, and other stakeholders)
- Determination by the program of cost per participant
- Budget report that reflects that benefits justify the cost
- Documents that reflect capacity building within program to ensure sustainability
- Documents reflecting program commits enough time for an effort to have intended sustained and substantial impact

## D. Replication and Scalability: Does the program demonstrate that it is replicable and scalable?

### ACCOMPLISHED

Program documents how it can be scaled or replicated and offers tools to support such scaling up or replication.

Program regularly communicates information to new sites to support scaling up or replication.

Program demonstrates that it is adaptable to appropriate new sites and works with local sites to adapt to local conditions. There is strong fidelity of implementation among sites.

### DEVELOPING

A process for scaling up and replicating the program is offered, but it is not well documented.

Program provides information on scaling up and replication, but only on an ad hoc basis.

Program is documented so it can be replicated, but it does not account for local conditions that may affect implementation. Fidelity of implementation is weak or unproven.

### UNDEVELOPED

There is no effort to show how the program might be scaled up or replicated at other sites.

Program does not plan to promote scaling up or replicating.

Program is tied exclusively to a specific site because of its unique resources, personnel, or other requirements.

#### Sample evidence:

- Documents reflecting how program can be scaled or replicated, possibly including a landscape analysis for new sites
- Documents reflecting how program can/will support scaling or replication
- Budget report that reflects that benefits as a result of scalability/replicability justify the cost
- Documents (i.e. strategic plan) identifying potential opportunities and/or challenges
- Documents reflecting concrete plans to take advantage of opportunities (i.e. matching funds agreements) and/or plans for addressing potential challenges (i.e. contingency plan)

## E. Partnerships: Does the program create high-impact partnerships where beneficial?

### ACCOMPLISHED

Recognizing that it lacks certain expertise or competencies, the program partners with other competent organizations.

Program identifies and partners with organizations that have already done work that can help it reach its goals or magnify its impact.

Program has documented how staff or volunteers build strong relationships with educators, community members, and program participants they work with.

### DEVELOPING

Other organizations or businesses are brought in on an ad-hoc basis to perform discrete tasks, but partners are not included in planning stages, and their relevant competencies aren't fully integrated into the project design.

Program bases its work on relevant prior work by other local organizations, but it does not explore partnerships with those organizations that could extend its impact.

Program staff or volunteers are learning how to build strong relationships with educators, community members, and program participants.

### UNDEVELOPED

Though the organization lacks the competencies to reach its goals, it does not partner with organizations that can supply those competencies.

Program makes no effort to build on the work of others or identify partners that could extend its impact.

Program staff or volunteers do not have the skills required to build relationships with key stakeholders.

Sample evidence:

- Documents (i.e. letters of support, work plans with defined roles) that reflect partnerships (either sustained or as needed) that: a) provide needed expertise, competencies, or capacities; or b) experience that will help guide or inform the progress of the program

## F. Capacity: Does the program have the capacity to meet its goals?

### ACCOMPLISHED

The program has been active in STEM learning in the past and has a track record of accomplishing STEM education goals with the target audience.

The program clearly articulates how its staff, infrastructure, internal expertise, and other resources support the project.

Staff or volunteers know STEM subject matter and have a command of pedagogy promoting STEM practices.

Where necessary, program provides staff or volunteers with effective professional development on STEM content and practices pedagogy and/or skills in building strong relationships. Alternatively, program provides staff or volunteers with outside resources and training.

### DEVELOPING

The program has some track record in reaching educational goals but not in STEM, not to the extent proposed, or not with the identified target audience.

The program demonstrates that it has enough resources and staff to do the work, but it is not clear that its staff have the time or expertise to do the work.

Staff or volunteers have the STEM subject matter knowledge but may have too little experience with project-based learning or vice versa.

Program offers staff or volunteers professional development in some aspects, but neglects it in others. Alternatively, program offers no professional development of its own, but directs staff or volunteers to outside resources and training.

### UNDEVELOPED

Though the program is not new to STEM learning, it cannot demonstrate any track record of accomplishing its goals.

The program makes no attempt to demonstrate that it has the staff, infrastructure, or expertise to carry out the project.

Staff or volunteers lack sufficient depth in STEM subject matter and cannot demonstrate experience with project-based learning.

Program offers staff or volunteers no training or direction on STEM content and practices pedagogy and/or skills in building strong relationships.

#### Sample evidence:

- Organizational chart with roles and responsibilities of program staff
- Education and training (certifications, licenses, etc.) background of all staff (i.e. Bio sketches, CVs, or resumes)
- Evaluation reports of progress (internal and/or external)
- Staff meeting agendas and/or notes
- Program management plan (including regular meeting schedules, decision logs, internal communication plan, etc.)
- Proof of completion of or ongoing involvement in STEM-specific professional development
- Proof of involvement in professional activities (i.e. conferences, meetings, community outreach)

## G. Challenging and Relevant Content: Is the STEM content challenging and relevant for the target audience?

### ACCOMPLISHED

Program is clearly and explicitly aligned with current and relevant local, state, or national standards. For out-of-school (OST) programs, content is aligned with what students are learning in school or provides enrichment beyond what is offered in school.

Program materials and experiences clearly reflect high expectations for all participants.

Program provides opportunities for real world applications of STEM where possible.

Program prompts participants to apply or transfer STEM content to new or unexpected situations.

### DEVELOPING

Program states that it is aligned with standards and/or school activities but does not clearly demonstrate the strength of that alignment.

Program acknowledges the need for high expectations for participants but does not clearly spell out what those expectations are.

Program makes an effort to relate STEM learning to real-world applications, but those applications are not always clear, they are forced, or they undermine the rigor of the STEM content.

Program offers opportunities to apply or transfer content knowledge, but they are artificial or inconsistent.

### UNDEVELOPED

Program pays no attention to local, state or national standards or what is currently being taught in school.

Program emphasizes only lower level skills.

Program makes no attempt to link content to real world STEM applications.

Program focuses primarily on recall of knowledge and/or routine skills.

#### Sample evidence:

- Written curriculum clearly and explicitly aligned to local, state, or national standards
- Program description that clearly addresses high expectations for participants well beyond minimum competency
- Curriculum materials, lesson plans – including student materials (as opposed to solely teacher materials), schedule of program activities, student work, and assessments, specifically including real-world applications and/or prompts for participants to apply their STEM knowledge to novel problems/situations
- Student outcome data
- Internal and/or external evaluation reports

## H. STEM Practices: Does the program incorporate and encourage STEM practices?

### ACCOMPLISHED

Program creates an environment where staff or volunteers foster students becoming active participants in their learning.

Program promotes STEM practices by encouraging participants to: ask questions and/or define problems; develop and use models; plan and carry out investigations; analyze and interpret data; use mathematics and computational thinking; construct explanations and/or design solutions; engage in argument from evidence; obtain, evaluate, and communicate information; and attend to precision.

Program explicitly demonstrates how it builds skills like critical thinking, problem-solving, creativity, collaboration, and teamwork.

Program prompts participants to be innovative, by having them create new ideas or products in an unscripted fashion.

### DEVELOPING

At times, the program allows participants and staff/volunteers to work together as active learners, but, as a rule, the instructor drives the learning.

Activities are hands-on but do not consistently encourage STEM practices. Some hands-on activities are routine and focus on the 'right answers'.

Program explicitly aims to promote skills like critical thinking, problem-solving, creativity, collaboration, and teamwork, but it does not clearly specify how.

Innovation is discussed, but not used to create new ideas or products.

### UNDEVELOPED

Staff or volunteers lead instruction with little opportunity for participants to become active learners.

The program does little or nothing to incorporate or encourage STEM practices.

Program makes no clear attempt to engage participants in skills like critical thinking, problem-solving, creativity, collaboration, and teamwork.

Program does not address innovation. Participants are not expected to create new ideas or products in an unscripted fashion.

#### Sample evidence:

- Curriculum materials, lesson plans, schedule of program activities, deidentified student work, and assessments specifically addressing active and problem-based learning activities (i.e. open-ended research, asking relevant questions, designing problems; carrying out investigations, etc.)
- Student outcome data
- Internal and/or external evaluation reports

# I. Inspiration: Does the program inspire interest and engagement in STEM?

## ACCOMPLISHED

Program creates excitement by providing positive experiences and dispelling negative misconceptions about STEM.

Program helps participants connect STEM content to career opportunities that require a strong STEM background.

Program clearly shows how it connects STEM to participants' own interests and experiences.

## DEVELOPING

Program aims to inspire but does little to provide positive experiences and dispel negative misconceptions about STEM.

Program occasionally helps participants connect STEM content to real-world careers, but those connections are not always clear or consistent.

Program relates STEM to participants' experiences, but only occasionally.

## UNDEVELOPED

Program makes little or no attempt provide positive experiences and dispel negative misconceptions about STEM.

Program makes little or no attempt to help participants connect STEM content and careers that use STEM knowledge.

Program does not connect STEM to participants' experiences.

### Sample evidence:

- Pre/Post participant surveys
- Transcripts of interviews/focus groups with participants and/or staff
- Time tracking of particular program activities
- Written observations of program at work

## J. Underrepresented Groups: Does the program identify and address the needs of underrepresented groups?

### ACCOMPLISHED

Program explicitly identifies and addresses needs of groups that are underrepresented in STEM fields.

Program accommodates diverse learners' needs through tailored instruction. Where appropriate, technology promotes attention to individual students' needs, diverse interests, and different learning styles.

Program ensures that individual participants spend the time on task they need to accomplish their learning goals. Learners can learn at their own pace.

Program demonstrates that it successfully reaches underrepresented groups through targeted recruitment efforts.

### DEVELOPING

Program can be used successfully with underrepresented groups, but makes no explicit attempt to address their needs.

Instructors check participant progress regularly to address learning gaps. Program may use technology to aid instruction, but the technology does not always adapt to students' individual learning needs.

Program specifies ample time on task, but it is not clear that participants in greatest need will be able to make the time commitment required to see results. There is only one instructional method and pace.

Program plans targeted recruitment efforts but lacks mechanisms to document its success.

### UNDEVELOPED

Program's structure and content is most likely to appeal to students who are already well represented in the STEM pipeline.

Instructors do not attempt to diagnose or address individual learners' challenges. Program neglects opportunities to use technology to address diverse learning needs.

Program does not consider the time different participants will need to spend on task to make meaningful progress. Most of the STEM instruction is delivered to the whole class, and learners are expected to absorb content delivered at the instructor's pace.

Program has no recruitment efforts to reach underrepresented groups and no evidence that it is actually reaching those groups.

#### Sample evidence:

- Student/participant demographic data
- Program description
- Mission/vision or goal statement for program
- Existing needs assessment data that was used for planning or ongoing evaluation
- Evaluation report/s that demonstrate that the defined need is being met and/or the needs of underrepresented groups are being addressed
- Documents reflecting recruitment of underrepresented groups
- Documents reflecting accommodations (time, resources, additional support) provided to participants to allow for individual learning goals
- Samples of differentiated instruction (i.e. lesson plans; student work samples; assessments)
- Documents reflecting use of technology to promote individual attention
- Student outcome data

## APPENDIX D

### Idaho-Specific PD Rubric

#### Idaho STEM Action Center:

#### STEM Professional Development Program Proposal

STEM professional development programs that meet Change the Equation's criteria for "accomplished" or "promising" programs will be included in the Change the Equation STEMworks database (<http://changetheequation.org/stemworks>). To be considered for the Idaho STEM Action Center Scale-Up Initiative, STEM professional development programs must also answer questions that address objectives specific to this Idaho initiative.

#### Idaho STEM Professional Development Program Proposal Guidelines:

- A select number of programs will be identified for Idaho STEM Action Center Scale-Up.
- Budgets must be clearly defined to the "smallest unit", ideally an individual educator or school.
- Programs must be scalable with fidelity in all Idaho communities.
- No more than two proposals may be submitted by a single provider.
- Program proposers who seek feedback and insight on their program may request the collective advice of managers and evaluators through the program officer only, in order to ensure fairness, equal opportunity, and neutrality on the part of the network managers and evaluators.

#### Idaho Specific STEM Professional Development Program Proposal Objectives:

*Meeting the CTEq "accomplished" or "promising" criteria, will ensure that applicant programs embrace and include the key elements of professional development in their programs, and is the basic requirement for consideration for Idaho STEM Action Center Scale-Up. Further, successful Scale-Up applications must answer Idaho specific questions and demonstrate how they meet Idaho specific objectives. To meet these, programs must:*

- Provide educators with strategies to better engage with educators in other disciplines, create and teach interdisciplinary programs, and evaluate interdisciplinary work.
- Have the human and resource capacity to be replicable anywhere in Idaho regardless of community size or location.
- Have the human and resource capacity to be sustainable anywhere in Idaho regardless of community size or location.
- Be based on current best-practices, research and data and 1) immerse participants in inquiry and model inquiry forms of teaching; 2) be intensive and sustained; 3) engage teachers in concrete tasks and be based on teacher

experiences with students; 4) deepen teacher content skills; and 5) be grounded in a common set of professional development standards. See Supovitz JA and HM Turner (2000) J Res Sci Teach 37(9):963-80.

- Communicate strategies, methodologies, and content that can be used by educators to effectively engage all learners in an integrated approach to STEM, including traditionally underrepresented populations such as female students, ethnic minority groups, students living in rural communities and those of low socioeconomic status. Provide educators strategies to better embed the practice of 21<sup>st</sup> century skills in their teaching. Go to <http://www.p21.org/about-us/p21-framework> for more information about 21st century skills.

**Timeline:**

- August 22, 2016 – STEM Professional Development Program Provider application opens.
- October 4, 2016 – STEM Professional Development Program Provider application closed.
- December 2, 2016 – Programs notified of selections
- December 14, 2016 – Complete STEM Professional Development Program descriptions for statewide announcement.

**Idaho Specific STEM Professional Development Program Proposal Elements:**

***Applicant Please Note:** Attachments are not allowed unless specifically noted in the instructions, although you are welcome to reference websites within the body of the narrative to which reviewers may view additional information. There is no assurance that reviewers will view your links, however.*

**1. Interdisciplinary Aspects: Does the project integrate multiple disciplines?**

Accomplished (4-5)	Developing (2-3)	Undeveloped (0-1)
Project explicitly demonstrates how it integrates at least one STEM discipline with one or more other STEM or non-STEM disciplines	Project mentions multiple disciplines, but does not clearly specify how they will be integrated into the program.	Project makes no clear attempt to engage participants in multiple disciplines
Project unambiguously integrates or merges disciplines beyond STEM.	Project attempts to integrate or merge disciplines beyond STEM.	Project makes no clear attempt to integrate or merge disciplines beyond STEM.
Project explicitly demonstrates how it addresses Idaho content standards and/or specifies content objectives where Idaho content standards do not exist in multiple disciplines.	Project explicitly aims to address content standards and/or specific content objectives where specific Idaho content standards do not exist in multiple disciplines, but does not clearly specify how.	Project makes no clear attempt to meet standards or specific objectives in multiple disciplinary areas.

In 350 words or less, describe ways that your program will help educators promote interdisciplinary learning. Interdisciplinary learning relates to or involves two or more academic disciplines that are usually considered distinct. It consciously applies methodology and language

from multiple disciplines to examine a central theme. To access the Idaho Content Standards: <http://www.sde.idaho.gov/academic/standards/index.html>

**2. Replicability in Idaho: Does the program demonstrate the human and resource capacity to be replicated in any Idaho communities regardless of size or location?**

Accomplished (4-5)	Developing (2-3)	Undeveloped (0-1)
Project demonstrates how it can be scaled and replicated in Idaho communities regardless of size or location and offers tools to support it.	A process for replicating the program in Idaho communities regardless of community size or location is offered, but it is not well documented.	There is no effort to show how the project might be scalable to sites regardless of community size or location in Idaho.
Project regularly communicates results publicly to promote replication in Idaho to new sites of all sizes and locations.	Project provides information to other sites but only on an ad hoc basis, when requested and not to communities of all sizes and locations in Idaho.	There is no effort to show how the project might be scalable to sites of all sizes and locations in Idaho.
Project demonstrates that it can be replicated and adapted to many new sites and local conditions in Idaho.	Project is documented so it can be replicated, but it does not account for local conditions that may affect implementation.	Project is tied exclusively to a specific or only a few sites because of its unique resources, personnel or other requirements.

In 300 words or less, describe how your program can be scaled and replicated in Idaho. Demonstrate that the program can adapt to diverse new sites and conditions, regardless of the size of the community or its location. Successful scale-up programs should demonstrate the capacity to expand the delivery model beyond the original site and sustain continuity of program outcomes over time. Describe program capacity. What infrastructure in Idaho will you establish or utilize to sustain the program as it grows? If possible, provide examples of successful program expansion/replication to communities of different sizes and geographic remoteness.

**3. Sustainability in Idaho: Does the program demonstrate the human and resource capacity to be sustainable in Idaho communities regardless of their size or remoteness?**

Accomplished (4-5)	Developing (2-3)	Undeveloped (0-1)
Plans are clear for sustaining the program in limited resource settings and regardless of community size or location.	Opportunities to sustain the program have been identified, but they are more hopeful than viable in some settings.	No viable plan or commitment to ensure the program’s long-term survival in communities of all sizes and locations is presented.
Projected benefits to teaching and/or learning justify the cost per participant and are likely to be affordable in communities with limited resources.	The cost per participant is high but justified, and there is a viable plan to make the program affordable in communities with limited resources.	The program cannot demonstrate that it will be affordable in communities with limited resources.

In 300 words or less, describe your program’s potential for sustainability in Idaho in limited resource settings including small and remote communities. If possible, provide examples.

**4. Professional Development: Does the professional development address STEM teaching and learning criteria?**

Accomplished (4-5)	Developing (2-3)	Undeveloped (0-1)
Includes the theory and modeling of common practices of STEM disciplines of solving problems, gathering and synthesizing information, using models, using technology to develop/demonstrate conceptual understanding, and communicating findings.	Discusses, but does not model common practices of STEM disciplines	Does not or minimally addresses the common practices of STEM disciplines.
Supports development of educators’ conceptual understanding of content.	Focuses on development of content knowledge but not the conceptual understanding of content.	Does not address conceptual understanding or competency.
Ensures rigorous academic concepts are coupled in a real-world context, student assessment tasks resemble real-world reading and writing, and the environment is learner-centered.	Includes some, but not all of the practices listed.	Does not or minimally addresses the practices listed.
Provides sustained support for implementation including provider support, stakeholder engagement, educator leadership and collaboration, and career awareness	Provides implementation support, but support is not sustained and/or does not engage all stakeholders.	Does not demonstrate a plan for support beyond the initial training.
Project explicitly demonstrates how it builds critical thinking, problem-solving, creativity and teamwork skills.	Project explicitly aims to promote these skills but it does not clearly specify how.	Project makes no clear attempt to engage participants in these skills.

All PD programs are expected to provide professional development that will enhance teachers’ content knowledge and provide them with pedagogical skills to provide instruction based on these criteria. In 300 words or less, please provide a detailed description of how the professional development associated with your project will address the STEM teaching and learning criteria and career awareness.

**5. Engaging All Learners: Does the project provide the tools to equip educators to effectively engage all learners in an integrated approach to STEM?**

Accomplished (4-5)	Developing (2-3)	Undeveloped (0-1)
Clearly communicates strategies, methodologies, and	Clearly communicates strategies, methodologies, and	Does not or poorly communicates strategies,

content that can be used by educators to effectively engage all learners in an integrated approach to STEM, including Idaho target groups of females, rural students and racial/ ethnic minorities and students with low socioeconomic status.	content that can be used to effectively engage all learners in an integrated approach to STEM for some but not all of Idaho's target groups.	methodologies, and content that can be used to effectively engage all learners in an integrated approach to STEM.
Ensures content is accessible and can be modified to accommodate all learners.	Content is accessible but there is limited evidence that methods can be adapted to accommodate all learners.	Content is not accessible and there is limited evidence that methods can be adapted to accommodate all learners.
Identifies and communicates diverse role models related to the program content, and conveys the importance of exposing students to relevant role models.	Identifies and communicates diverse role models related to the program content, or conveys the importance of introducing students to relevant role models but not both.	Does not communicate diverse role models related to the program content, or the importance of introducing students to relevant role models.
Project integrates best practices for traditionally underrepresented populations by teaching content and language simultaneously. There is evidence of differentiation of materials – readings and products are available that require less language for students to show rigorous learning without language barriers.	Project aims to integrate best practices for traditionally underrepresented populations in STEM, beyond teaching vocabulary.	Project just teaches vocabulary.
Communicates effective strategies for educators to help all students believe in their own ability to understand and do STEM.	Communicated strategies are not clearly research-based and/or are applicable to only some students.	Does not communicate effective strategies for educators to help all students believe in their own ability to understand and do STEM.

In 300 words or less, provide evidence of the program's effectiveness in successfully engaging all students, including those from groups under-represented in STEM. Under-represented groups include African Americans, Latinos, females, low socio-economic status, and/or rural, etc. Demonstrate how the project integrated or merges disciplines beyond STEM which may include Arts and Culture when possible and appropriate.

## 6. Project Resources: Does the project ensure the budget to handle significant growth?

Accomplished (4-5)	Developing (2-3)	Undeveloped (0-1)
Project budget is presented with clarity and sufficiently meets the needs of the project for optimal success.	Project budget has areas of question regarding its ability to meet the needs of the project, but overall seems adequate, or the program overestimates the resources required.	Project budget is unreasonable and not adequately justified.

## APPENDIX E

### Focus Group Procedures and Questions

A series of focus groups will be formed (2-4 depending on the number of attendees). Groups will consist of approximately 8 – 10 teachers who are attending a math and science educators' conference at Timberline High School in Boise, Idaho on October 6<sup>th</sup>, 2016. Focus groups of approximately 45 minutes will be conducted. The session will begin with Angela first obtaining content, laying the ground rules and then asking educators to complete the educator PD survey. After 5 minutes of silent writing, educators will be brought back together to share their findings.

- I. Intro and Ground Rules
  - a. Obtain Consent – hand out consent form and thank them for coming
  - b. Start Tape Recorder
  - c. **SAY:** We are conducting a focus group to ensure the PD opportunities offered by the STEM Action Center meet the needs of Idaho educators. STEM AC has significant funds which are dedicated to support high quality STEM professional development. It is critical that we get this right for Idaho educators and their students. I am here so you can share your thoughts and opinions related to PD so we can support you being even more successful in your classroom.
  - d. **SAY:** You will each receive a six question survey. Please fill that out silently and then we will come back together as a group and discuss the survey. Please only fill out the PRE focus group ranking in questions 6.
  - e. **Handout** survey
  - f. **WAIT** about 5 minutes and bring back together
  - g. **SAY:** Here are a few ground rules that we need to follow:
    - i. **THE GROUP SHOULD DO THE TALKING (NOT ME).**
      - It is requested that everyone participate.
      - I may call on you if I haven't heard from you in a while.
    - ii. **THERE ARE NO RIGHT OR WRONG ANSWERS**
      - Every person's experiences and opinions are important.
      - Speak up whether you agree or disagree.
      - I would like to hear a wide range of opinions.
    - iii. **WHAT IS SAID IN THIS ROOM STAYS HERE**
      - Please feel comfortable sharing your ideas even when sensitive issues come up
    - iv. **WE WILL BE TAPE RECORDING THE GROUP**
      - We want to capture everything you have to say.
      - We will not identify anyone by name in our report. You will remain anonymous.
- II. Q&A related to PD
  - a. Could anyone briefly describe a typical professional development experience?

- i. Follow Ups: What components of the PD did you find beneficial? What did you enjoy the most? Afterwards, what did you find yourself applying to your classroom (if anything)?
- b. What words did you associate with high quality PD?
- c. What words did you associate with low quality PD?
- d. Focus on Q6 from survey**
  - i. Discussion on Q6 (pre-discussion rankings)
  - ii. Which item did you rank as the most important? Why did you feel this way?
  - iii. Did some else have a similar ranking?
  - iv. Did some else have a different ranking?
  - v. Can you share an experience that led you to rank that characteristic so high/low?
  - vi. What might PD look like if it were to prioritize this characteristic?
  - vii. Do you agree with this? (Or, How do you feel about that?)
  - viii. Are there other recommendations that you have, or suggestions you would like to make?
  - ix. Are there other things you would like to say before we wind up?
- e. List of other potential follow up questions.**
  - i. What does PD do wrong/badly?
  - ii. What is some PD missing that you would like to see prioritized?
  - iii. Other **probes** to keep conversation moving
    - 1. Can you say more about that?
    - 2. Can you give an example?
    - 3. Jane says X. How about others in the group. What do you think?"
    - 4. How about you, Joe? Do you have some thoughts on this?
    - 5. "Does anyone else have some thoughts on that?"
    - 6. Can you help me understand what you mean?
- f. **SAY:** Thank you for participating in this focus group. Would you please take a moment to fill out the post-discussion rankings.
- g. Collect surveys, hand out raffle tickets and turn off recorder

APPENDIX F

**Pre-PD Questionnaire**

- 1) How many years have you been teaching?
  - a. 0-1 year
  - b. 2-4 years
  - c. 5-7 years
  - d. 8-10 years
  - e. 11+ years
  
- 2) Which subject areas do you currently teach? Please select all that apply.
  - a. Science
  - b. Technology
  - c. Engineering
  - d. Math
  - e. Other, please indicate: \_\_\_\_\_
  
- 3) On average, how many hours are your typical professional development experiences (STEM-related and otherwise)?
  - a. 0-8 hours (1 day)
  - b. 9-16 hours (2 days)
  - c. 17-24 hours (3 days)
  - d. 25-48 hours (4-6 days)
  - e. 49-72 hours (6-9 days)
  - f. More than 72 hours (over 10 days)
  
- 4) What are 3-5 words you would associate with '*high quality professional development*'?
  - a. \_\_\_\_\_
  - b. \_\_\_\_\_
  - c. \_\_\_\_\_
  - d. \_\_\_\_\_
  - e. \_\_\_\_\_
  
- 5) What are 3-5 words would you associate with '*low quality professional development*'?
  - a. \_\_\_\_\_
  - b. \_\_\_\_\_
  - c. \_\_\_\_\_
  - d. \_\_\_\_\_
  - e. \_\_\_\_\_

- 6) Please rank the following in order from most important to least important when experiencing professional development. Please use the scale from 1 (most important aspect of PD) to 9 (least important aspect of PD). Words below are listed alphabetically.
- a. \_\_\_\_\_ Connects two or more disciplines, interdisciplinary (i.e. math and science)
  - b. \_\_\_\_\_ Contains challenging and relevant content
  - c. \_\_\_\_\_ Fosters partnerships with others (i.e. educators/industry/higher ed/organizations)
  - d. \_\_\_\_\_ Learn how to engage diverse learners
  - e. \_\_\_\_\_ Learn new best practices in STEM
  - f. \_\_\_\_\_ Meets my professional needs
  - g. \_\_\_\_\_ PD takes place over several sessions (sustainability)
  - h. \_\_\_\_\_ Provides readily usable resources
  - i. \_\_\_\_\_ Teaches me how to share my knowledge with students

-Knowles questions related to adult learning:

- 7) Characteristics of YOU, the Learner.

- Please answer the following questions as strongly agree, agree, somewhat agree, somewhat disagree, disagree, strongly disagree

- a) I am an independent learner
- b) I prefer my learning to be self-directed
- c) I consider myself to be very internally motivated
- d) I feel that I bring a diverse background of knowledge to PD experiences
- e) I prefer PD that is problem-centered
- f) I prefer PD that is relevant to my content area
- g) When engaging in PD, it is important for me to know the reason for learning the material

- 8) What grade levels do you teach?

-Please select all that apply

- a. K-2
- b. 3-5
- c. 6-8
- d. 9-10
- e. 11-12

- 9) What do you hope to gain from this PD?

## APPENDIX G

### Post-PD Evaluation Feedback Survey

- 1) Which PD opportunity did you attend? (Select one of the 4 opportunities)  
-Add selected opportunities
- 2) How would you rate the overall quality of this PD opportunity? (Scale 1 – 5; Low = 1; Medium = 3; High = 5)  
  
1,2,3,4,5
- 3) Please explain why you rated the PD as such from the previous question?
- 4) How much time did you devote to this specific PD opportunity thus far?
  - a. 0-8 hours (1 day)
  - b. 9-16 hours (2 days)
  - c. 17-24 hours (3 days)
  - d. 25-48 hours (4-6 days)
  - e. 49-72 hours (6-9 days)
  - f. More than 72 hours (over 10 days)

Please give your opinions about working with your PD provider. To what extent... (Not at all, Some of the time, Most of the time, All of the time) (Questions 5 – 8 will be presented in a gridded format.)

- 5) Did you have adequate contact with the service provider?
- 6) Did you receive materials and resources in a timely manner?
- 7) Was the service provider responsive to your questions and needs?
- 8) Did your partnership with the service provider meet your overall expectations?

Please answer the following questions as strongly agree, agree, somewhat agree, somewhat disagree, disagree, strongly disagree (Questions 9 – 25 will be presented in a gridded format.)

(Darling-Hammond and Richardson, 2009)

- 9) The PD deepened my knowledge of content and how to teach it to students
- 10) The PD helped me understand how students learn specific content
- 11) The PD provided opportunities for active, hands-on learning
- 12) The PD enabled me to acquire new knowledge, apply it to practice, and reflect on the results with colleagues.

(Smith and Gillespie, 2007)

- 13) The PD made a strong connection between what I learned and my current work assignment
- 14) The PD helped me plan for application and to identify and strategize barriers to application

- 15) The PD focused on subject-matter knowledge.
- 16) The PD included a strong emphasis on analysis and reflection, rather than just demonstrating techniques.
- 17) The PD include a variety of activities.

From Iowa STEM PD Program (<http://iowastem.gov/sites/default/files/evaluation/2015-16-Iowa-STEM-Evaluation-Report.pdf>)

- 18) The PD helped me to better understand how to work engage diverse learners in STEM (i.e. females, low SES, students from rural communities, race/ethnicity)?
- 19) The PD showed me how to utilize more than one STEM subject in your classroom? (i.e. science *and* engineering, math *and* technology, etc).
- 20) I gained new knowledge and/or skills as a result of this PD.
- 21) I believe that I will receive the administrative support to implement most aspects of the PD
- 22) I have more confidence to teach STEM topics.
- 23) I have increased my knowledge of STEM topics.
- 24) I am better prepared to answer students' questions about STEM topics.
- 25) I have learned effective methods for teaching STEM topics.

Extended Response:

- 26) Describe challenges or barriers, if any, you faced in working with your PD provider.
- 27) What did you find helpful during the PD and would recommend to others? This might include helpful partners, administrative support, training, or unique local circumstances.
- 28) How will you implement what you learned from this PD into your teaching practices?
- 29) What additional supports do you need to be successful?
- 30) Would other educators benefit from this opportunity?
- 31) Should this PD be offered in future years? (i.e. Would you recommend this PD to others?).  
Please explain why or why not.