Can Missouri Become a National Computer Science/Information Technology Leader?

Prepared for the Missouri General Assembly Joint Committee on Education

by

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Joint Committee on Education

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EXECUTIVE SUMMARY

In Missouri, some 11,000 well-paying computer science jobs go unfilled annually. To address the situation, legislation that would allow students in Missouri's public schools to substitute a rigorous computer science course for a mathematics, science, or practical arts course required for high school graduation was on pace to become law. For reasons unrelated to the "course substitution" provision – Governor Parson vetoed SB 894 (2018). During the First Extra Session of the Second Regular Session of the 99th General Assembly, sections of SB 894 were recrafted to address the Governor's concerns and the measure ultimately became the truly agreed and finally passed HB 3. It was signed by Governor Parson October 30, 2018. The measures for K-12 computer science education contained in HB 3 are identical to those contained in the vetoed SB 894.

HB 3 requires the Missouri Department of Elementary and Secondary Education (DESE) to develop a high school graduation policy before July 1, 2019 to allow students to fulfill one unit of academic credit with a district-approved CS course for any math, science, or practical arts unit required for high school graduation. The law also requires DESE to convene workgroups to develop and recommend CS academic performance standards to be implemented beginning in the 2019-2020 school year for students in kindergarten through 12th grade. Under the law, a "Computer Science Fund" must be established to provide teacher professional development programs and DESE must develop a procedure by which teachers who demonstrate sufficient CS content knowledge can receive a special license endorsement. The provisions of HB 3 represent four of nine policy approaches suggested by Code.org -- a nonprofit organization and a leading provider of K-12 CS curriculum that describes itself as being dedicated to expanding access to computer science in schools. To greater or lesser extents, many states are adopting these sorts of policies.

Against the backdrop of the SB 894 debate, at its April 30, 2018 meeting, the Missouri General Assembly's Joint Committee on Education elected to examine Senator Gary Romine's query: Can Missouri become a national leader in computer science? During that same meeting, Representative Dean Dohrman suggested that the utility of liberal arts education be explored as well. Because the individual and societal benefits of broad-based liberal arts education are seldom considered in an environment that often posits economic and workforce issues as the primary purposes of education, this is an important and timely area for inquiry. Senator Romine proposed that an exploration of liberal arts education be "rolled into" the computer science inquiry. This suggestion well served and informed the overall exercise because the inquiry suggested that modifying the school curriculum to include and elevate the importance of computer science can indeed enhance liberal arts education while fulfilling both individual and societal educational purposes. However, because instructional minutes are limited, and because curricular choices have explicit and implicit consequences, it was cautioned that balances between liberal arts, hard science, and career curriculums be carefully considered when changes are proposed.

Theory was presented to suggest a broad based liberal arts education provides students with the requite schema to develop a strong ordered intellect which in turn provides the ability to explore, examine, and understand a wide range of ideas and topics. Liberal arts education exercises the mind in various disciplines to strengthen reasoning and thus enhances the most important ability of all – the ability to learn.

Courses in art, civics, ethics, history, literature, music, and social studies teach students about culture, morals, rights, civic responsibilities, and behavioral standards expected of individuals, employees, friends, family members, and citizens. It was posited that liberal arts education is an essential part of career preparation because the aforementioned curriculums help provide students with the soft skills (e.g., communication, critical thinking, work ethic, conscientiousness, and self-awareness) that have time-and-time again been cited as lacking in students by business and industry leaders. Furthermore, because recent research suggests that significant percentages of students are increasingly disillusioned with some bedrock principals of American culture – it was recommended that courses in American history, civics, and economics be re-examined for content and re-emphasized to contextualize the individual's role in the nation's economic system. It was asserted that decade's long workforce shortages (e.g., nursing, engineering, and mathematics and science teachers) may be due in part to increasingly popular attitudes/beliefs that are inconsistent with capitalistic representative democracy. Logically these sorts of beliefs and attitudes could be undermining economic and workforce development initiatives.

The inquiry suggested that the states with the most CS job opportunities (e.g., California, Texas, and Florida) had vibrant CS/ technology industries long before any K-12 educational policies related to CS curriculums were adopted and moreover -- those states have only recently adopted any policies related to computer science education. Without much research evidence to support such actions, many states have recently adopted policies similar to those suggested by Code.org presumably to address the same industry/workforce issues present in the Missouri economy. The inquiry suggested that the race among states to adopt largely identical CS educational policies may result in a stalemate – where the present CS leaders, as measured by job opportunities, will likely remain the leaders because no competitive advantage may be gained. For this reason and others – it was asserted that while HB 3 serves important educational purposes, it will probably not – in and of itself -- cause Missouri to become a national computer science leader.

Early research on the effects of increased opportunities to take CS in high school suggest broader participation and increasing enrollments of underrepresented groups in CS courses and in subsequent CS courses. Unintended outcomes of increased CS educational opportunities were also considered. Because computer science students share many of the same interests and characteristics of students in other STEM content areas – unless the pool of students does indeed expand -- students choosing to pursue CS careers might exacerbate critical shortages in other STEM areas (e.g., mathematics and science teaching, engineering, nursing). This should be closely monitored suggesting a fertile area for future research.

Talent for Tomorrow (2018) a joint effort between the Hawthorn Foundation, the Missouri Department of Economic Development, and the Missouri Department of Higher Education found that while there are indeed many thousands of unfilled CS jobs – which generally require four-year degrees existing primarily in three regions of the state -- there are far more high paying opportunities in education, healthcare, engineering, and nursing in EVERY area of the state. This situation calls into question the idea of creating a new curriculum to address workforce shortages in a particular industry while other well-paying job opportunities which often require less training have even greater needs for workers.

The plausibility of Missouri emerging as a national computer science leader was considered using a framework developed by Harvard Business School professor Michael Porter. Porter (1990, p. 78) defines clusters as “geographic concentrations of interconnected companies and institutions in a particular field.” The theory holds that concentrating particular firms, businesses, or industries in specific areas or regions creates competitive advantages. Porter (1998) describes industry clusters as the product of four factors he calls the “diamond of competitive advantage”: factor conditions, demand conditions, related and supporting industries, and firm strategy, structure, and rivalry. Factor conditions include the presence of a skilled labor force, specialized infrastructure, and educational institutions that benefit all cluster business.

Informed by cluster theory, it was asserted that the availability of a trained workforce is an essential, but nonetheless singular, part of what is needed for Missouri to become a national leader in computer science (or any other industry for that matter).

To lead, Missouri would need to develop CS clusters like those that exist in places like Palo Alto California or Atlanta Georgia. While theoretically possible, this was considered unlikely because research suggests that while billions have been spent and legislation (e.g., investment in specialized infrastructure, targeted financial incentives, and competition protections) has been enacted in other countries and regions to encourage the emergence of particular clusters -- especially technology clusters -- these efforts have mostly failed. For that reason, researchers have suggested that concentrating on identifying and bolstering potential or already existing clusters offers the best chance for intervention to produce real economic improvement. Important work to do just that has recently been completed in Missouri.

Talent for Tomorrow (2018) identified groups of industries that share supply chains or inputs such as workers, information, or goods to capture the linkages between those industries. Industries meeting these criteria were grouped into seven "opportunity clusters" They are:

- aerospace and defense
- agribusiness
- automotive and transportation
- energy solutions,
- entertainment and media,
- financial services,
- healthcare and life sciences.

Three "cross-clusters" (i.e., education, health care, and manufacturing) were identified that support all or nearly all of the opportunity clusters. While many of the identified industries certainly rely on CS/Information technology, CS and IT were not specifically identified by Talent for Tomorrow as Missouri opportunity clusters.

Research suggests that policy should not pick winners among clusters or potential clusters. Instead, government should seek to nurture and reinforce established and emerging clusters rather than trying to create the clusters it favors. Instead of aspiring to become a national leader in any particular industry, including computer science, research suggests that Missouri should support any and all clusters or possible emerging clusters. To do this Porter suggests that some environmental conditions may be augmented by policy to promote cluster development. A theory aligned approach for encouraging new clusters would involve improving overall business environment conditions by improving workforce skills, capital access, and infrastructure, streamlining rules and regulations, and supporting sophisticated local demand. In sum, cluster theory suggests environments conducive to the vigorous growth of a particular industry or set of related industries requires much more than the presence of an appropriate workforce.

Because of their complicated relationships and interconnectedness, it is important for policymakers to realize that initiatives intended to facilitate the emergence of particular industry clusters is an uncertain proposition at best. In fact, efforts to create technology clusters have more often than not failed. Ketels and Memedovic (2008) assert that when government intervention has been credited for the establishment of new clusters, the clusters had favorable locations as well as the appropriate environmental conditions for business. In other words, governments have intervened to create clusters that probably would have emerged anyway. This suggests that Missouri should place its policy resources where its strengths are and those strengths are probably best embodied by the "opportunity clusters" identified by *Talent for Tomorrow.*

Recommendation: *Coursework in computer science can fulfill education's individual and societal purposes. Moreover, computer science curriculum can be part of an enhanced broad-based liberal arts education. Therefore, it is recommended that computer science curriculums be made more available in Missouri schools as HB 3 encourages. However, because curricular modification has the potential to be extremely consequential to the cultural and socializing aspects of schooling, care must be taken to maintain balances between coursework for career, hard sciences, and curriculums more associated with liberal arts going forward.*

Lack of civic/societal awareness or responsibility and decreased abilities to problem solve and innovate among students may be due in part to dwindling liberal arts learning experiences or a systematic de-emphasis of the importance of those experiences. In other words, if educational programs overly emphasize hard science or career curriculums at the expense of liberal arts experiences, philosophic theory suggests students may become detached from larger societal concerns/constructs to such a degree that they may fail to appropriately understand their individual duties and roles and thus fail to properly participate. This could partially explain why students lack the soft skills employers say they need because while students may have trained to do a job, significant percentages may no longer buy into particular societal constructs (e.g., representative democracy, capitalism) that require traditional behaviors (e.g., soft skills) for successful participation. Thus proposals to replace or diminish foundational coursework with curriculums aimed toward particular careers or industries should be carefully considered.

In support of computer science and other career oriented curriculums, and in line with liberal arts education theory, it is recommended that liberals arts curriculums, particularly those in American history, American free market economic history/theory, and American civics be reexamined for content and improved to augment student understanding of the context and importance of individual career participation within a democratic capitalistic society.

Recommendation: *Because computers and computing permeate all aspects of modern society, opportunities to learn about the subject matter should be available to every Missouri student to fulfill education's multiple purposes. Furthermore, this inquiry has found that Missouri has robust and lucrative computer science opportunity environments in particular areas of the state but lacks the capacity, in terms of number of CS K-12 educational courses/programs to produce the number of qualified candidates needed to meet industry workforce needs. Therefore, Missouri should provide computer science curriculums while allowing for district and student choice/discretion regarding individual career goals and local workforce contexts.*

Emerging evidence suggests that polices like those contained in HB 3 (2018) can expand the pool of students interested in STEM courses and increase the number of students taking CS courses. However unintended consequences including the possible exacerbation of perennial shortages in other STEM occupations should be carefully monitored.

Recommendation: *Missouri is home to two of Computer Science Zone's 50 Cities and Towns With the Most Computer-Related Jobs (St. Louis ranked 28th and Kansas City ranked 43rd). However, for Missouri to become a national leader in the computer science industry it would need to eclipse or achieve parity with the current leaders (i.e., California, Florida, Ohio, Texas, Virginia). To accomplish this, several CS industry clusters would need to emerge in Missouri. This inquiry posited that while not impossible, the materialization of several Missouri CS clusters is unlikely in the near term – especially in light of Talent for Tomorrow initiative findings which found that while the Kansas City, Central, and St. Louis regions have significant needs for individuals trained to assume positions in the CS industry – it did not identify CS as a Missouri opportunity cluster.*

While policies like those suggested by Code.org and contained in HB 3 are intended to promote CS awareness and improve CS skills to expand the CS workforce -- in sum, cluster theory suggests environments conducive to the vigorous growth of a particular industry or set of related industries requires much more than the presence *of an appropriate workforce. Stated differently, Missouri should not expect that the presence of a suitable workforce will guarantee that a particular industry will emerge. Because most states are adopting very similar educational policies -- all aimed at improving CS education and bolstering CS workforces – it is hard to imagine that any state can achieve a competitive advantage by doing so.*

Because of their complicated relationships and interconnectedness, it is asserted that initiatives intended to facilitate the emergence of particular industry clusters is an uncertain proposition at best. In fact, researchers have found that efforts to create technology clusters have failed more often than not. Ketels and Memedovic (2008) assert that when government intervention has been credited for the establishment of new clusters, those clusters had favorable locations as well as the appropriate environmental conditions for business. In other words, governments have intervened in situations that likely would have occurred anyway.

Scholars in cluster theory warn that policymakers should avoid picking winners among clusters or potential clusters. Instead, they suggest nurturing and reinforcing established and emerging clusters rather than trying to create the clusters it favors. With this advice in mind, instead of aspiring to become a national leader in any particular industry -- including computer science -- research suggests that Missouri should support any and all existing clusters and possible emerging clusters. Clusters and emerging clusters in Missouri have been identified by the Talent for Tomorrow (TFT) initiative. They are aerospace and defense, agribusiness, automotive and transportation, energy solutions, entertainment and media, financial services, healthcare and life sciences, education, health care, and manufacturing.

Porter (1998, 2000) suggests a theory aligned approach for encouraging the aforementioned Missouri opportunity clusters (and clusters in general). Therefore this effort recommends that Missouri pursue policies designed to:

- *improve overall business environment conditions*
- *improve workforce skills, capital access, and infrastructure*
- *streamline rules and regulations,*
- *support sophisticated local demand.*

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BACKGROUND

Occupations focused on computers, computing, and coding are significant sources of high wage jobs worldwide. According to Code.org, a nonprofit dedicated to expanding access to computer science in schools and increasing participation by women and underrepresented minorities, these opportunities account for over half of all projected new jobs in Science Technology Engineering and Mathematics (STEM) fields. This makes computer science (CS) credentials very much in demand. In Missouri, more than 11,000 computing jobs remain unfilled with an average salary of $82,000 (significantly higher than the average salary in the state of $44,620).

The degree to which computers and computing have become ubiquitous in modern society is impossible to describe. CS and Information Technology (IT) is present in virtually every area of endeavor leading many to believe CS should be taught to students as basic foundational knowledge. However, at this point in time it seems there are limited opportunities for Missouri students to learn about computers and computer programing. According to Code.org Missouri graduated only 1,138 computer scientists in 2015 and just 631 exams were taken in advanced placement (AP) CS by high school students in 2017. These statistics suggest an educational system that is producing far fewer candidates than are needed by industry.

In response to what is perceived as a tremendous shortfall in Missouri's workforce – House Bill 3 (HB 3) was passed to address an apparent deficiency/omission in the state's K-12 curriculum – universal access to CS courses in the public schools. To incentivize schools to offer CS courses and to encourage students to enroll in them, the Missouri Department of Elementary and Secondary Education (DESE) must now develop a high school graduation policy before July 1, 2019 to allow students to fulfill one unit of academic credit with a district-approved CS course for any math, science, or practical arts unit required for high school graduation.

To accommodate Missouri School Improvement Program (MSIP) requirements, the measure stipulates that students must have either taken all courses requiring end-of-course exams or be on track to take all courses requiring MSIP accountability exams to receive credit toward high school graduation. To help ensure students would be made aware of the ramifications of making such a decision, school districts are required to advise students electing to substitute a CS course for a mathematics credit that some institutions of higher education may require four units of math for admission. Furthermore, parents of students choosing to take a CS course to fulfill a fourth math credit are required to sign and submit a document acknowledging that taking CS instead of a fourth unit of mathematics could have an adverse effect on college admission decisions.

HB 3, requires DESE and the Coordinating Board for Higher Education to develop and implement academic requirements for computer science courses offered in high schools (9th-12th grade). In addition, DESE must convene a workgroup of Missouri computer science (CS) educators to develop and recommend CS academic performance standards for students in kindergarten through 12th grade as required by Mo. Rev. Stat. §§ 160.514, 160.526, and 161.855, as amended by CCS #2 SS SCS HB 1490 (2014). DESE will then develop written CS curriculum frameworks that can be used by school districts beginning in the 2019-2020 school year. In addition, DESE must develop a procedure to allow licensed teachers with sufficient CS content knowledge to receive a special teaching endorsement.

HB 3 made clear that Missouri is taking serious and significant actions in an effort to create a more CS and IT capable citizenry/workforce. The question is will these sorts of actions cause the state to acquire national leadership status so Missouri's citizens can take advantage of high wage CS industry jobs? The Missouri General Assembly's Joint Committee on Education committed to explore this question and to do so, several areas of literature were examined.

- Theory and philosophy regarding the multiple purposes of education.
- Theory and value of liberal arts education
- Educational policy approaches to promote CS education
- Regional development cluster theory

THE PURPOSE OF EDUCATION

Philosophical Perspectives

Long before state constitutions addressed education (education is famously not addressed in the U.S. constitution) and long before state education agencies were established to oversee and improve it, philosophers dedicated a great deal of thought to describing the various purposes for education. Ancient (e.g., Aristotle, Plato, Socrates) and more contemporary (e.g., Dewey, Locke, Rousseau, Mo Tzu) philosophers have agreed – the overarching societal purpose of education is to inculcate and reinforce the institutions, traditions, and values a society considers essential for the protection and reproduction of the prevailing social order (Noddings, 1995; Reed & Johnson, 1996). Therefore, control of education and in particular *curriculum* is exceptionally powerful. Because education is essential for the health and stability of society at large it is inherently and undeniably political.

Purposes of schooling in American society have been addressed in detail by great American educational philosophers including John Dewey, George Counts, and Mortimer Adler. Dewey believed the primary purpose of education is not so much to prepare students to live a useful life -- but to teach them how to live pragmatically and immediately in their current environment. To this point Dewey wrote:

> The purpose of education has always been to everyone, in essence, the same—to give the young the things they need in order to develop in an orderly, sequential way into members of society. This was the purpose of the education given to a little aboriginal in the Australian bush before the coming of the white man. It was the purpose of the education of youth in the golden age of Athens. It is the purpose of education today, whether this education goes on in a one-room school in the mountains of Tennessee or in the most advanced, progressive school in a radical community. But to develop into a member of society in the Australian bush had nothing in common with developing into a member of society in ancient Greece, and still less with what is needed today. Any education is, in its forms and methods, an outgrowth of the needs of the society in which it exists.

—John Dewey, “Individual Psychology and Education,” The Philosopher, 12, 1934

George Counts, a leading progressive educator in the 1930s, asserted education’s purpose has less to do with preparing individuals to live independently and is more about preparing individuals to live as members of a society -- an important distinction. Unlike Dewey‘s focus on more pragmatic more occupation oriented motives for education -- Counts believed the purpose is to provide the requisite skills needed for community participation and moreover to alter the prevailing social order if need be (Counts, 1978). While Counts would certainly allow space for occupation and vocation for full “community participation,” unlike Dewey, it seems that Counts emphasis is centered more on society and social order -- making his philosophy of education decidedly more political than Dewey’s.

Adler (1982), suggested three central purposes for education: the development of citizenship, personal growth or self-improvement, and occupational preparation. Four major purposes were suggested by deMarrais and LeCompte (1995):

- Intellectual purposes (e.g., development of mathematical and reading skills);
- Political purposes (e.g., assimilation of immigrants);
- Economic purposes (e.g., job preparation, workforce development); and
- Social purposes (e.g., development of social and moral responsibility).

Tyack (1998) took a simpler approach suggesting that education is tied to social and economic needs. More recently sociologists have distilled education's purpose to a single reason -- to serve a practical credentialing function (Labaree, 1997).

Bowles, Gintis, Carnoy, and Apple of the Marxist/Postmodern schools of philosophy would certainly agree with the notion that education serves to protect and reproduce the prevailing social order. However, they assign more ominous intent. In particular, Marxist/Postmodernists espouse that the social relationships reinforced by education in capitalist societies not only serve the purpose of preparing citizens for hierarchically arranged occupational and class structures -- but also reproduce domination structures. In short, this school believes knowledge taught in schools is instrumental for the reproduction of the politics of capitalism (Essays, UK, 2013).

This very short discussion of education's purpose is intended to illuminate substantial agreement among the philosophical schools. Both ancient and modern philosophies substantially agree that education and schooling exist to provide broad life preparation for the individual, but equally and maybe more importantly, education also serves to reproduce the kind of society -- along with its institutions and values -- that are consistent with prevailing traditions. These traditions certainly include preparation for occupation but this is in no way the whole or possibly even the most important purpose. Rather, this philosophic examination of education's purpose suggests that because any part of the schooling experience should integrate with the central societal purpose (i.e., to inculcate and reinforce society's essential values in order to protect and reproduce the prevailing social order) *any modification of the school curriculum*, and for that matter, *any modification of the cultural or socializing aspects of schooling are extremely consequential with potential for long-lasting and significant individual and societal effects -- both intended and otherwise*. Curricular modification is therefore profoundly serious and should be undertaken soberly, deliberately, and with careful mindfulness of ramifications.

Liberal Arts Education

What skills should education teach to fulfill its societal purpose (i.e., to reinforce, inculcate, and re-inculcate the institutions, traditions, and values a society considers essential for the protection and reproduction of the prevailing social order (Noddings, 1995; Reed & Johnson, 1996)) -- or what slate of abilities and competencies must one have to become a responsible, functioning, effectively participating member of society? The intellectual capacities to think independently, and generate creative thoughts, consider sophisticated questions of ethical and moral importance, respect the rights of others, value art and beauty, and solve problems in numerous settings and various areas are generally believed to be the product of a well-rounded or *liberal arts education*. Liberal arts education has been characterized as a training center for the mind because it is exercised and enlarged by varied intellectual experiences.

Owens (2012) enumerated the intellectual skills cultivated by liberal arts education. They are:

1) Ability to speak and write effectively in more than one language
2) Ability to think critically, and to form one's own opinions by evaluating arguments and evidence rationally, and without prejudice;
3) Enhanced ability in mathematics, and in scientific reasoning;
4) Ability to analyze literature and art to appreciate beauty and artistic creativity, for both pleasure and intellectual enrichment;
4) Ability to engage questions of ethics and morality and to recognize responsibility for oneself and society;
5) Ability to apply acquired knowledge and analytical skills to new situations, so as to find solutions to new problems that arise in an increasingly globalized and fast-changing world.

Liberal arts education is intended to develop a strong ordered intellect which provides the ability to explore and examine a wide range of ideas and topics. It exercises the mind in various disciplines (e.g., history, literature, physics, art) to strengthen reasoning and thus the ability to learn. By using diverse approaches to orient and order thinking skills to address diverse disciplines, students develop the attention, concentration, and persistence skills needed to understand arguments, logic, and lines of reason that allow for discrimination between ideas and to discern between the important and the inconsequential.

Liberal arts education trains the mind in the processes of learning. No curriculum, teacher or training program can teach students all they need to know -- whether that knowledge is needed for occupation or otherwise. Rather, the accumulated experience of learning in a multitude of areas and settings teaches the skill of learning itself (e.g., idea organization, comprehend new material, ability to learn faster, thoroughly, and permanently). In addition, the more that is learned the easier it becomes to learn because the mind attaches new information to relevant preexisting schema. During learning the brain creates new approaches, pathways, and categories as well as new strategies and habits to increase speed and efficiency. Learning precipitates learning because old knowledge builds upon and clarifies new knowledge.

It is clear that broad based learning experiences are vitally important to individuals and to society at large, however courses and curriculum more associated with liberal arts curriculum (e.g., art, history, physical education, music, and sociology) are often regarded as less important than courses more associated with developing skills needed for career. When budgets are tight courses associated with liberal arts can be diminished or eliminated in favor of subject matters deemed to be more important to college or career success. These are extremely consequential decisions because while all courses contribute to a well-rounded experience, the make-up of the entire educational experience makes and remakes society by exposing students to particular value sets, dispositions, traditions, skills, abilities, and cultural expectations while deemphasizing others by default.

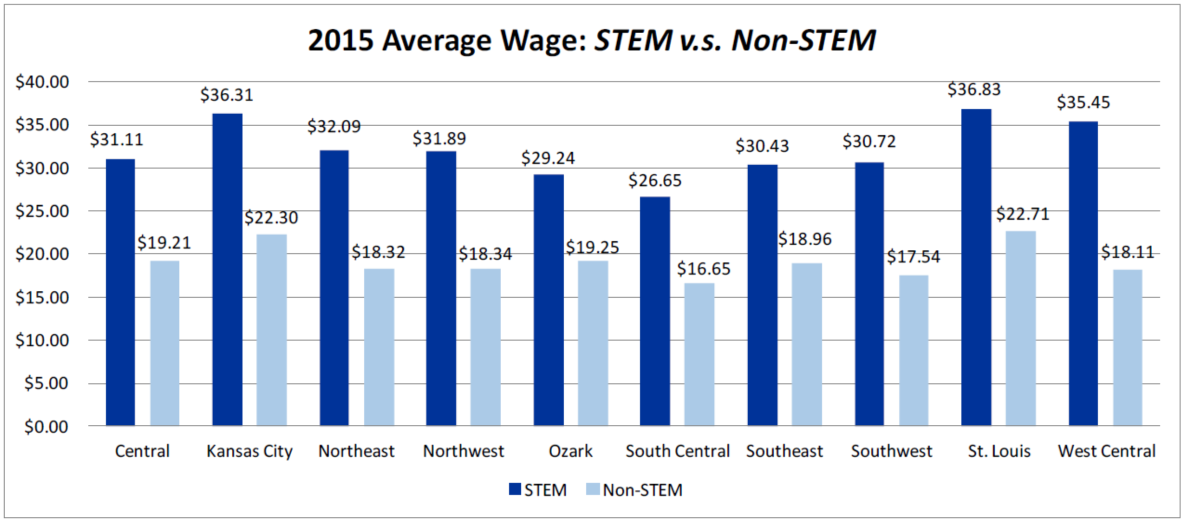
Because instructional time is limited, minutes used for one discipline often come at the expense of others. Moreover, choices regarding the use of instructional time send strong signals to students about what society values and what it does not. Owens (2012) asserted a liberal arts education allows individuals to join the societal conversation or in his words "to read, discuss and test the great ideas proposed by the great thinkers and writers of the world." This examination of liberal arts education underscores the notion that general knowledge and depth of general knowledge produces new ideas, understanding and creativity. Moreover, liberal arts education fulfills education's many purposes both for the individual and for society at large.

MISSOURI'S COMPUTER SCIENCE CAPACITY

According to the US Census Bureau, six percent of the 2011 United States workforce was employed in STEM jobs -- half in computer occupations. In 2011, Kansas City and St. Louis had over seven percent of their workforces employed in science, technology, engineering, and mathematics (STEM) occupations and according to the U.S. Bureau of Labor Statistics, the most concentrated Missouri STEM occupation is agricultural and food science technicians – a relatively small category when compared to other STEM occupations. Concentrations in larger STEM occupations (1,000+) such as computer user support specialists, applications software developers, and computer systems analysts also exist in Missouri.

The Missouri Economic Research and Information Center (MERIC) determined the number of STEM and Non-STEM openings in Missouri from February 1, 2016 – July 31, 2016 were over 200,000. Twelve percent were STEM occupations. The St. Louis region had the highest percentage of STEM openings at 18 percent, followed by Kansas City (13 percent), and the central region (i.e., Columbia, Jefferson City, Rolla) seven percent. The top five industry employers with the most STEM job openings in Missouri are Washington University, Express Scripts, Monsanto, Centene Corporation, and Honeywell. The average wage for Missouri STEM related jobs is $35.49 an hour -- $14.50 more than the average wage for non-STEM jobs.

Figure 1. 2015 Average Wage: STEM vs Non-STEM



Source: U.S. Bureau of Labor Statistics (2015).

Figure 2. STEM Occupations Top Openings 2014-2024

Career Grade	Occupation Title	2014 Estimated Employment	2024 Projected Employment	Growth Openings	Replacement Openings	Total Openings	2015 Average Wage
A+	Computer Systems Analysts	11,504	14,052	2,548	1,480	**4,028**	$89,754
A	Computer User Support Specialists	15,382	17,367	1,985	1,979	**3,964**	$49,403
A+	Software Developers, Applications	12,376	14,420	2,044	1,769	**3,813**	$92,663
B	Computer Programmers	8,628	8,053	0	2,126	**2,126**	$78,827
A+	Computer and Information Systems Managers	6,269	7,270	1,001	739	**1,740**	$125,809
B+	Network and Computer Systems Administrators	8,622	9,198	576	1,109	**1,685**	$73,448
A	Mechanical Engineers	3,682	3,985	303	1,166	**1,469**	$81,306
B+	Civil Engineers	3,800	4,084	284	1,122	**1,406**	$76,550
B+	Sales Reps, Tech and Scientific Products	5,378	5,653	275	1,106	**1,381**	$71,707
B+	Industrial Engineers	3,798	3,971	173	1,114	**1,287**	$85,774
B+	Database Administrators	3,259	3,552	293	702	**995**	$79,014
B+	Electrical Engineers	3,571	3,733	162	787	**949**	$94,831
B+	Architectural and Engineering Managers	2,498	2,570	72	765	**837**	$129,178
A	Clinical, Counseling, and School Psychologists	1,979	2,365	386	424	**810**	$67,571
A	Web Developers	2,000	2,530	530	257	**787**	$61,664
B	Computer Network Support Specialists	3,664	3,907	243	471	**714**	$58,231
A	Software Developers, Systems Software	3,079	3,333	254	440	**694**	$100,153
A	Biochemists and Biophysicists	1,204	1,554	350	322	**672**	$81,982
A	Information Security Analysts	2,137	2,525	388	275	**663**	$78,186
B	Life, Physical, and Social Science Technicians, All Other	1,156	1,260	104	485	**589**	$48,004

Sources: Bureau of Labor Statistics (BLS) and the Division of Occupational Employment Statistics (OES) data used to define STEM occupations and wages. Occupational projections and Career Grades developed by the Missouri Economic Research and Information Center (MERIC).

MISSOURI Department of Economic Development

MERIC TIMELY TARGETED INTELLIGENT

Figures 1 and 2 indicate that STEM careers in computer and computer science related fields pay, in many cases, considerable more than the Missouri average. So why do workforce shortages stubbornly persist in these areas? The answer to that question is undoubtedly multifaceted and while aspects that impact student interest in pursuing and working in CS and other STEM occupations should be fully explored in future inquiries -- one aspect of the problem is likely related to the capacity of the educational system to prepare candidates.

Statistics provided by the Missouri Department of Elementary and Secondary Education (DESE) (Table 1) suggest that a substantial number of Missouri students are now taking courses described by DESE as “computer science related.” DESE indicates 449 advanced placement (AP) computer science examinations were taken in 2017 in the subjects of Computer Science A (CSA) (328) and Computer Science Principles (CSP) (121). By gender, males far outnumber females in CS AP courses. Two hundred-eighty males, and 48 females took the CSA test and 86 males and 35 females took the CSP examination. The number of schools that offer an AP CS courses is small. In 2017 fifteen schools offered the courses (12 CSA and 3 CSP).

Table 1. Missouri Computer Science Course Statistics

Course Name	Total Enrollment	Total Teachers	Total Schools
BUSINESS TECHNOLOGY	4,997	234	214
COMPUTER APPLICATIONS	22,113	502	394
COMPUTER PROGRAMMING	2,329	85	81
COMPUTER SCIENCE I	60	9	9
COMPUTER SCIENCE II	22	2	2
DIGITAL COMMUNICATIONS	1,125	28	21
E-BUSINESS	9	2	3
WEB DESIGN	4,916	180	170
COMPUTER INTEGRATED MANUFACTURING	285	20	21
COMPUTER SCIENCE APPLICATIONS	806	32	31
COMPUTER SCIENCE AND SOFTWARE ENGINEERING	2,126	69	66
COMPUTER SCIENCE ESSENTIALS	338	10	10

Source: DESE 2018

Data from Code.org, a nonprofit and leading provider of K-12 CS curriculum that describes itself as being dedicated to expanding access to computer science in schools, basically concur with MERIC’s figures. According to Code.org, Missouri has over 11,200 open computing jobs with an average salary of $82,050. Code.org further asserts Missouri produced 1,138 computer science graduates in 2015 (17 percent of whom were female). In concurrence with DESE’s statistics, Code.org reports 631 exams were taken in AP CS by high school students in Missouri in 2017 (466 CSA and 165 CSP). Twenty percent of those exams were taken by females, 29 exams were taken by Hispanic or Latino students, Black students took 34 exams, and one exam was taken by a student who identified as American Indian/Alaska Native.

Sixty-nine Missouri schools (21 percent of schools with general AP programs) offered an AP computer science course in 2016-2017 (18 percent offered CSA and 10 percent offered CSP) which was 22 more than the previous year. Data also indicates that students take fewer AP exams in computer science than in any other STEM subject area. Significantly, just a single computer science teacher graduated from Missouri universities in 2016 (Code.org, 2018).

Provided that enrolment in high school computer science (CS) coursework, AP or otherwise, would lead to increased numbers of CS college majors and a subsequent increase of those available to fill CS industry employment opportunities (two areas where there is a lack of well-designed research studies) statistics such as those just presented suggest that Missouri does not have the capacity, in terms of number of CS educational programs, to produce the workforce needed by CS employers. At a minimum, the statistics suggest the industry needs roughly ten times more candidates than are now being produced. Unfortunately, that situation will probably persist or worsen considering Missouri produced only one qualified CS teacher in 2016. Simply put, even if a flood of ready and willing students suddenly decided to enroll in CS coursework, they (especially rural students) would find insufficient opportunities. Moreover, even if those students could enroll in rigorous CS classes -- they would likely be taught by teachers without CS certification.

Missouri's Computer Science Education Policy

Missouri certainly isn't the only state facing CS/STEM workforce issues. Generally, the nation's growing demand for technical skills, combined with seeming lack of student interest in engaging in demanding STEM related coursework (more on that later), leave most states facing the same circumstance – too few qualified candidates to fill ever growing STEM occupational vacancies. To address the situation, many states are now in the process of adopting very similar policies.

In its publication *Nine Policy Ideas to Make Computer Science Fundamental to K-12 Education,* Code.org has posited policy suggestions that most states are implementing, in whole or in part, to improve CS educational capacity. They are:

1. Create a state plan for K-12 computer science
2. Define computer science and establish rigorous K-12 computer science standards
3. Allocate funding for rigorous computer science teacher professional learning and course support
4. Implement clear certification pathways for computer science teachers
5. Create programs at institutions of higher education to offer computer science to preservice teachers
6. Establish dedicated computer science positions in state and local education agencies
7. Require that all secondary schools offer computer science with appropriate implementation timelines
8. Allow computer science to satisfy a core graduation requirement
9. Allow computer science to satisfy an admission requirement at institutions of higher education

Figure 3 provides a concise snapshot of Missouri educational policy, both pre and post HB 3, in relation to Code.org's nine policy suggestions.

Figure 3. Missouri Tracking – Nine Code.org CS Polices

	State Plan	Standards	Funding	Certification	Preservice Incentives	State CS Position	Require HS to Offer	Grad require	Higher Ed Admit
Pre HB 3	No	No	No	No	No	No	No	No	No
Post HB 3	No	√	√	endorsement	No	No	No	√	No

Source: Code.org State Tracking 9 Policies (Public)https://docs.google.com/spreadsheets /d/1YtTVcp QXoZz0IchihwGOihaCNeqCz2HyLwaXYpyb2SQ/pubhtml#

1. Create a state plan for K-12 computer science

Making CS a fundamental part of Missouri's system of education will mean adding an entirely "new" subject to the curriculum. This is no minor undertaking and will require a number of philosophical, policy, and implementation issues to be considered and addressed. Code.org suggests that such a plan may need to include full K-12 subject matter standards, policies and funding to enable all high schools to offer at least one rigorous CS course, and mechanisms for the funding of CS professional development and course support.

Missouri does not have a state plan for K-12 CS which articulates the goals for computer science and strategies for accomplishing those goals. HB 3 does not require that such a plan be produced.

2. Define computer science and establish rigorous K-12 computer science standards

Code.org advances the idea that high-quality standards create expectations for students and are needed to properly prepare them to succeed in a variety of both educational and career settings. The organization cautions that confusion between *computer science* and *computer literacy* or larger technology education goals (i.e., teaching basic technology literacy and/or how to use technology) has been a barrier in some states to the establishment of rigorous curriculum designed to teach students to *create* technology through studying CS.

HB 3 requires DESE to convene workgroups to develop and recommend computer science academic performance standards for students in kindergarten through 12th grade. These standards will be implemented beginning in the 2019-2020 school year. In addition, DESE will develop CS curriculum frameworks for district use.

3. Allocate funding for rigorous computer science teacher professional learning and course support

At this point in time, CS courses in Missouri are electives -- which is likely an important reason why CS teacher professional development and support has not been a high priority for school districts. Code.org suggests states should provide the necessary resources for professional development to prepare teachers to teach CS. Furthermore, Code.org believes funding should be prioritized for districts that demonstrate efforts to engage underrepresented student groups to maximize the number of individuals with backgrounds in, and familiarity with, CS concepts.

HB 3 provides for the "Computer Science Fund" to provide CS teacher professional development programs. The State Board of Education will award grants from the fund to eligible entities to:

(a) Reach new and existing teachers with little computer science background;
(b) Use effective practices for professional development;

(c) Focus training on the conceptual foundations of computer science;
(d) Reach and support historically underrepresented students in computer science;
(e) Provide teachers with concrete experience with hands-on, inquiry-based practices; and
(f) Accommodate the particular needs of students and teachers in each district and school.

4. Implement clear certification pathways for computer science teachers

As was touched on previously, expansion of high quality K-12 CS education is impossible if qualified teachers aren't available to implement curriculum. Therefore, creating clear avenues for CS teacher certification is essential. Code.org asserts existing incentives for teacher endorsements in mathematics (or other high-need STEM fields) should be replicated for endorsements in CS.

HB 3 requires DESE to develop a procedure by which teachers who hold a certificate of license to teach and demonstrate sufficient CS content knowledge to receive a special endorsement on his or her license signifying his or her specialized CS knowledge. At this time Missouri has no clear certification pathways for computer science teachers, however because HB 3 allows teachers to receive a license endorsement, the certification box in Figure 3 indicates "endorsement."

5. Create programs at institutions of higher education to offer computer science to preservice teachers

According to Code.org, teacher shortages in computer science (CS) could be alleviated by exposing more preservice teachers to CS during required coursework or by creating specific pathways for CS teachers (e.g., those preparing to be mathematics or science teachers could become CS teachers by taking a minimal number of computer science courses within preparation programs). Code.org asserts states could create scholarships for preservice teachers to take computer science (CS) courses as part of their preparation program. Further, states might create funding incentives for higher education institutions that expand CS preparation programs in schools of education and create specific CS certification pathways.

Missouri has not established programs at institutions of higher education to offer computer science to preservice teachers as a formal part of their preparation programs. Neither has it created funding incentives for higher education institutions to expand CS preparation programs in schools of education at this point in time.

6. Establish dedicated computer science leadership positions in state and local education agencies

Code.org envisions the promotion and expansion of CS throughout the states by creating dedicated computer science positions within state and local education agencies. It believes officers will advance new policies for the expansion of K-12 CS, teacher professional development, district engagement and capacity building. Code.org believes that creating a statewide computer science leadership position within DESE would send the message that CS is important at all levels of education in Missouri. This office could encourage districts to provide funding for similar positions at the local level. Code.org believes establishing computer science positions at the state level will ensure rapid statewide scaling and support and facilitate the sharing of best practices between school districts.

Missouri has not established -- nor did HB 3 suggest -- the creation of a dedicated computer science position in DESE or in local education agencies.

7. Require that all secondary schools offer computer science with appropriate implementation timelines

Code.org asserts that underrepresented student groups are less likely to attend a school that offers computer science. To encourage students to take CS in middle and high school -- Code.org believes states should start by embedding CS in the K-5 curriculum. In addition, Code.org suggests that states adopt policies that require schools to offer at least one rigorous CS course in high school.

We have seen that many Missouri high schools do not offer CS courses and Missouri does not require high schools to offer CS courses. However, with the passage of the Missouri Course Access and Virtual School Program CCS/HCS/SS/SCS/SBs 603, 576 & 898 (2018) any eligible student can enroll in DESE approved online courses and those courses will be paid for by the school district or charter school. This allows districts of all sizes to offer rigorous CS courses in high school which would provide the infrastructure needed for the state to require CS courses in all high schools at some point in the not too distant future.

8. Allow computer science to satisfy a core graduation requirement

Some states have adopted policies allowing CS courses to satisfy core high school graduation requirements. However, many states do not list CS as a core course for graduation. Code.org suggests that CS be a credit that can substitute for a core requirement. Code.org says states that allow CS to substitute for a core graduation requirement experience 50 percent more enrollment in AP CS courses and increased underrepresented group participation.

HB 3 allows computer science (CS) to count for a core graduation requirement. The law requires DESE to develop a high school graduation policy before July 1, 2019 to allow students to fulfill one unit of academic credit with a district-approved CS course for any math, science, or practical arts unit required for high school graduation. Adopting this policy approach appears to offer promise in increasing Missouri's capacity to increase the number of citizens with CS training.

9. Allow computer science to satisfy an admission requirement at institutions of higher education

According to Code.org, admission policies at many institutions of higher education do not allow CS courses to satisfy mathematics or science entrance requirements. Logically then, the organization believes that even while CS courses count as a high school graduation requirement in many states – the fact that CS courses cannot satisfy higher education entrance requirements discourages enrollment in high school CS courses. For this reason, Code.org believes aligning secondary and post-secondary policies would incentivize students.

Missouri does not have an overarching policy requiring CS to count as a core admission requirement at institutions of higher education and HB 3 did not change that. Code.org suggests that admission policies that do not include rigorous computer science (CS) courses as meeting a core entrance requirement, such as in mathematics or science, discourage students from taking such courses in secondary education.

While HB 3 does not require the state's higher education institutions to allow high school CS courses to satisfy an admission requirement -- the bill does seem to acknowledge, and make accommodations for, misalignment of core high school graduation requirements and higher education admission standards. HB 3 requires DESE and the Coordinating Board for Higher Education to cooperate in developing and implementing academic requirements for CS courses offered in 9th-12th grade – this would ostensibly ameliorate alignment concerns. Furthermore, in an effort to minimize student/parent misunderstandings, HB 3 requires school districts to alert students electing to substitute a CS course for a mathematics unit that some institutions of higher education may require four units of math for admission. By requiring parents of students choosing to take a CS course instead of a fourth mathematics unit to sign and submit a document acknowledging that taking the CS course could adversely affect college admissibility -- the measure provides for parental advice and consent.

Missouri Education Policy Compared to Other States

Across the Mississippi River to the east, Missouri shares borders with Illinois, Kentucky, and Tennessee; Nebraska, Oklahoma, and Kansas to the west; Iowa to the north; and Arkansas to the south. Figure 4 depicts the degree to which Missouri and its neighbors (as well as the other 42 states) have adopted policies similar to Code.org's nine policy suggestions. Listed in order of the number of policies adopted, or in the process of being adopted, they are: Arkansas (all 9 policies), Kentucky (5 policies, 1,2,4,8, and 9), Iowa (4 policies, 2,3,4 and 7), Illinois (3 policies, 4,8, and 9), Oklahoma (3 policies, 2,4, and 8), Tennessee (2 policies, 4 and 8), Kansas (1 policy, 2), Nebraska (1 policies), Missouri (0 policies pre HB 3, 4 policies, 2,3,4, and 8 post HB 3).

Arkansas is the only state bordering Missouri that has adopted all nine polices. Kentucky and Iowa have enacted about half of the suggested policies (five and four polices respectively). With the passage of HB 3, Missouri has adopted four policies, and the remaining states have adopted, or are in the process of adopting, three policies or less -- including one state (Nebraska) that have adopted one.

Figure 4. State Tracking – Nine Code.org CS Polices as of January 14th 2019

State abbv	State name	1. State plan	2. Standards	3. Funding	4. Certification	5. Preservice incentives	6. State CS position	7. Require HS to offer	8. Count (grad req't)	9. Higher ed admission
AK	Alaska	No	In progress	No	No	No	No	No	No	No
AL	Alabama	In progress	Yes	Yes	No	No	No	No	Yes	No
AR	Arkansas	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AZ	Arizona	No	Yes	Yes	Yes	No	No	No	District Decision	No
CA	California	In progress	Yes	No	Yes	No	Other	No	District Decision	Yes
CO	Colorado	No	No	Yes	No	No	Yes	No	District Decision	Yes
CT	Connecticut	In progress	Yes	No	No	No	Yes	No	No	No
DC	District of Columb	No	No	No	Yes	No	No	No	Yes	No
DE	Delaware	No	Yes	No	No	No	No	Yes	Yes	No
FL	Florida	No	Yes	No	Yes	No	Yes	Yes	Yes	No
GA	Georgia	Yes	In progress	Yes	Yes	No	Yes	No	Yes	Yes
HI	Hawaii	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No
IA	Iowa	No	Yes	Yes	Yes	No	Yes	Other	No	No
ID	Idaho	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IL	Illinois	No	No	No	Yes	No	No	No	Yes	Yes
IN	Indiana	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
KS	Kansas	No	In progress	No	No	No	No	No	No	No
KY	Kentucky	No	In progress	No	Yes	No	No	No	District Decision	Yes
LA	Louisiana	No	No	No	Yes	No	No	No	Yes	Yes
MA	Massachusetts	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes
MD	Maryland	In progress	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ME	Maine	No	No	No	No	No	No	No	No	No
MI	Michigan	No	In progress	Other	No	Yes	No	No	Yes	No
MN	Minnesota	No	No	No	No	No	No	No	Yes	No
MO	Missouri	No	In progress	No	In progress	No	No	No	Yes	No
MS	Mississippi	No	Yes	No	Yes	No	No	No	Yes	Yes
MT	Montana	No	In progress	No	Yes	Yes	No	No	No	No
NC	North Carolina	Yes	Soon in progress	Yes	Yes	No	In progress	No	Yes	No
ND	North Dakota	No	In progress	No	Yes	No	No	No	Yes	No
NE	Nebraska	No	No	No	No	No	No	No	Yes	No
NH	New Hampshire	Yes	Yes	No	Yes	No	Yes	Yes	District Decision	No
NJ	New Jersey	No	Yes	Yes	Yes	No	No	Yes	Yes	No
NM	New Mexico	No	Yes	No	No	No	No	No	Yes	No
NV	Nevada	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
NY	New York	No	Soon in progress	Yes	Yes	No	No	No	District Decision	No
OH	Ohio	No	Yes	No	Yes	Yes	In progress	No	Yes	No
OK	Oklahoma	No	Yes	No	Yes	No	Yes	No	Yes	No
OR	Oregon	No	No	No	No	No	No	No	District Decision	No
PA	Pennsylvania	No	Yes	Yes	No	No	No	No	Yes	No
RI	Rhode Island	Yes	Yes	Yes	No	No	No	Other	Yes	No
SC	South Carolina	No	Yes	No	Yes	No	No	Yes	Yes	Yes
SD	South Dakota	No	No	No	No	No	No	No	Yes	No
TN	Tennessee	No	No	No	Yes	No	No	No	Yes	No
TX	Texas	No	No	No	Yes	Yes	No	Yes	Yes	Yes
UT	Utah	Other	Yes	Yes	Yes	Yes	No	No	Yes	No
VA	Virginia	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
VT	Vermont	No	No	No	Yes	Yes	No	No	No	No
WA	Washington	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
WI	Wisconsin	No	Yes	No	Yes	Yes	No	No	Yes	No
WV	West Virginia	No	Yes	No	Yes	No	No	Yes	Yes	No
WY	Wyoming	Yes	In progress	Other	Yes	No	Yes	Yes	Yes	Yes
Puerto Rico	Territory	No	No	No	No	No	No	No	No	No
Guam	Territory	No	No	No	No	No	No	No	No	No
US Virgin Islands	Territory	No	No	No	No	No	No	No	No	No
Northern Mariana	Territory	No	No	No	No	No	No	No	No	No
American Samoa	Territory	No	No	No	No	No	No	No	No	No
		10	28	20	35	13	17	15	43	17

Source: Code.org State Tracking 9 Policies (Public)
https://docs.google.com/spreadsheets/d/1YtTVcpQXoZz0IchihwGOihaCNeqCz2HyLwaXYpyb2SQ/pubhtml

Figure 5. Missouri Neighboring State Tracking – Nine Code.org CS Polices

POLICY	State Plan	Standards	Funding	Certification	Preservice Incentives	State CS Position	Require HS to Offer	Grad Require	Higher Ed Admit	
Policy Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**STATE TOTAL**
Arkansas	√	√	√	√	√	√	√	√	√	9
Kentucky		√		√				District Decision	√	4
Iowa		√	√	√		√	Other			5
Illinois				√				√	√	3
Oklahoma		√		√		√		√		4
Tennessee				√				√		2
Kansas		In progress								1
Nebraska								√		1
Missouri Pre HB 3										0
Missouri Post HB 3		√	√	endorsement				√		4
Number of States with Policy	1	6	3	7	1	3	2	7	3	

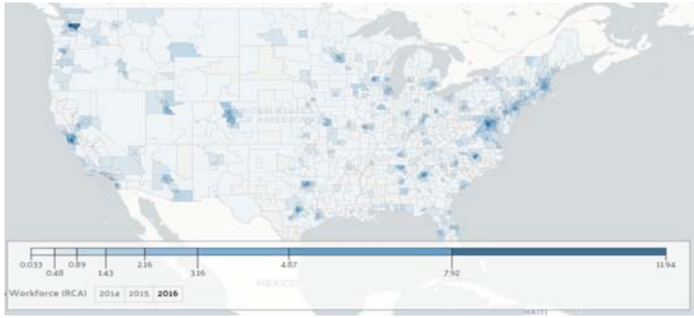
Source: Code.org State Tracking 9 Policies (Public) https://docs.google.com/spreadsheets/d/1YtTVcpQXoZz0IchihwGOihaCNeqCz2HyLwaXYpyb2SQ/pubhtml#

In terms of the most adopted/popular policies, Missouri and six of its neighbors have or will implement clear certification pathways for CS teachers (policy 4), six define computer science and establish rigorous K-12 computer science standards (policy 2), and seven allow CS to satisfy a core graduation requirement (policy 8). Only three states permit computer science to satisfy an admission requirement at institutions of higher education (policy 9). All other polices were adopted by two states or less.

Figure 6 represents a Data USA map depicting the regions in the United States that have comparative advantage in the Computer Systems Design Industry Group category which encompasses a wide variety of CS occupations.

The map shows locations that employ more people in the Computer Systems Design Industry Group than expected -- given both the size of that location's overall labor pool and the national size of the Computer Systems Design Industry Group (CSDIG).

Figure 6. Data USA Computer Systems Design – OPPORTUNITIES 2016



Source: Data USA Computer Systems Design – OPPORTUNITIES 2016 at https://datausa.io/profile/naics/5415/#workforce

A glance at the graphic indicates that, with notable exceptions, large concentrations of people employed in the CSDIG are basically located on the east and west coasts and in large population centers. This data largely aligns with that of *Computer Science Zone*, an information organization providing resources and rankings for CS and IT students.

In their publication, *50 Cities and Towns With the Most Computer-Related Jobs*, Computer Science Zone (CSZ) compiled a list of 50 American cities with the most CS/tech related jobs. CSZ observes computer-related job postings over the latest five-month period in over 80 regions. That data is then combined with top cities for existing computer-related jobs. CSZ explains the city ranking and jobs available are subject to change because of the extremely fluid condition of the computer-related job market. To avoid giving more entries to one part of the country than necessary (e.g., all the cities/towns in Silicon Valley, California), *Computer Science Zone* uses regions instead of cities at times. The ranking also considers and provides the top industries and employers in each city.

According to Computer Science Zone (2018) the top five states by number of cities or regions in the top 50 are California with 6; Texas - 5; Florida - 4; Ohio - 4; and Virginia - 4. Generally, these states have long histories in science and technology enterprises and very strong CS related industries with the most prominent and powerful technology companies calling those states home.

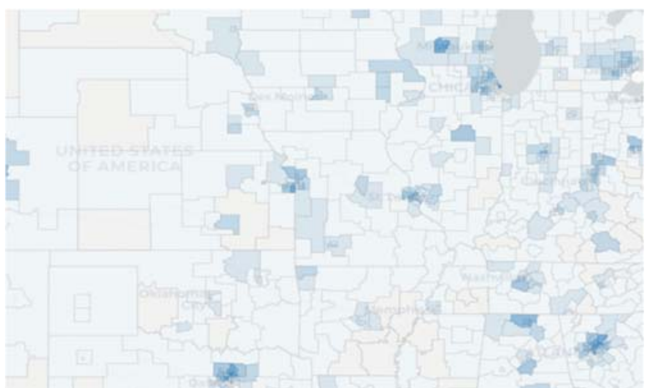
Figures 7 and 8 indicate that concentrations of CS related jobs in Missouri and its bordering states, with exceptions for the larger population centers, are not particularly strong in comparison to the top five states as ranked by the number of cities or regions they have in the top 50. Missouri and its eight bordering states do have seven cities that appear in Computer Science Zone's *50 Cities and Towns With the Most Computer-Related Jobs* -- one of which appears in the top ten (Chicago at

4th). However, the next highest ranking cities are in the bottom half of the 50 states (i.e., St. Louis, MO (28th), Louisville, KY (39th), Oklahoma City, OK (40th), Overland Park, KS (42nd), Kansas City, MO (43rd), and Nashville, TN (50th)) (Computer Science Zone, 2018).

<u>Figure 7. Computer Science Zone Top Cities for Computer-Related Jobs -- Missouri and Border States</u>

Source: Computer Science Zone – Top Cities for Computer-Related Jobs at https://www.computer sciencezone.org/most-computer-related-jobs/

<u>Figure 8. Data USA Computer Systems Design – OPPORTUNITIES 2016 – Missouri and Border States</u>



Source: Data USA Computer Systems Design – OPPORTUNITIES 2016 at https://datausa.io/profile/naics/5415/#workforce

Figure 9 indicates that in comparison to Missouri and its bordering states, on average the top five states for CS related jobs have adopted slightly more of the nine Code.org suggested CS policies with Ohio adopting the lowest number of policies (4) and Virginia adopting the most (7) (Code.org, 2018). All of the top five states have implemented clear certification pathways for computer science teachers (policy 4) and, all -- with the exception of California which leaves the decision to individual school districts -- allow CS to satisfy a core graduation requirement (policy 8). These two policies (i.e., 4 and 8) were most popular among the group of states that include Missouri and its bordering states as well as among the 50 states as a whole.

Figure 9. Computer Science Zone Top Five States – Nine Code.org CS Polices

POLICY	State Plan	Standards	Funding	Certification	Preservice Incentives	State CS Position	Require HS to Offer	Grad Require	Higher Ed Admit	
Policy Number	1	2	3	4	5	6	7	8	9	STATE TOTAL
California	In progress	√		√		√		District Decision	√	6
Florida		√		√		√	√	√		5
Ohio		√		√	√	In progress		√		5
Texas				√	√		√	√	√	5
Virginia		√	√	√	√	√	√	√		7
Number of States with Policy	1	4	1	5	3	4	3	5	2	

Source: Code.org State Tracking 9 Policies (Public) https://docs.google.com/spreadsheets/d/1YtTVcpQXoZz0IchihwGOihaCNeqCz2HyLwaXYpyb2SQ/pubhtml#

This is likely an outcome of how CS educational policy advocates/entrepreneurs/lobbyists focus their initial legislative efforts. This is logical because if policy requires that CS satisfy a core graduation requirement and teachers can become certified to teach the courses -- the remaining policies are far more likely to be proposed and adopted subsequently.

DOES THE ADOPTION OF POLICIES SUGGESTED BY CODE.ORG WORK?

It would appear that particular Code.org efforts may be increasing the number of students who are taking CS courses. One reason why is because Code.org helps train teachers and recruit students for a Computer Science Principles (CSP) class. According to USA Today, Code.org partnered with the College Board to help train and fund high schools to offer CSP as a standard high school course and at the advanced college credit level. The CSP curriculum is meant to encourage creativity with a mix of problem-solving activities, information about internet and cybersecurity, and discussions about technology responsibility and equity. The class is intended to be more accessible with far less coding than AP Computer Science Class A (CSA), an intensive class teaching Java. By being more accessible, CSP was designed to bring computer science studies to more students and schools (Suppe, 2018).

College Board data suggests dramatic increases in student participation. 135,992 students took AP computer science exams in 2018 which represents a 31 percent increase from 2017. African-American students taking AP CS courses rose 44 percent to 7,301, Hispanic and Latino participation increased 41 percent to 20,954, female participation rose 39 percent to 38,195, and the number of rural students taking AP CS exams increased by 42 percent to 14,184 (Suppe, 2018). These data certainly suggest increasing participation -- ostensibly due to increased opportunity and accessibility. However, time and more research are needed to describe the possible workforce effects of expanded CS curricular opportunities. After all, several courses in mathematics are required for high school graduation in many states including Missouri -- but even compulsory coursework in mathematics HAS NOT alleviated severe shortages in mathematics and professions related to mathematics including engineering and acute shortages of mathematics teachers that have persisted for several generations.

It would seem plausible to surmise that states that have adopted multiple CS educational policies would be those states with the largest CS industries and/or the most opportunity to be employed in CS occupations. Generally, the states that have the largest CS industry opportunities (or have the most top 50 cities within their borders) are the states that have adopted more policies -- but that isn't always the case. For example, Chicago (ranked number 4) is the only city appearing in *Computer Science Zone Top 10 Cities for Computer-Related Jobs* in the region that includes Missouri and its neighbors. However, Illinois has adopted just three of the Code.org suggested policies -- albeit the policies adopted were the most popular (i.e., policy 4 (teacher certification pathways), policy 8 (meets a high school graduation requirement), as well as policy 9 (can count for college admission)).

Arkansas has adopted the full slate of Code.org polices yet, according to Figures 7 and 8, Arkansas has relatively low CS opportunity levels and does not have a single *Computer Science Zone* top 50 city or region. On the other hand, even while Missouri has yet to implement any of the Code.org measures and Kansas has adopted just one (Code.org policy two – learning standards), Missouri has one of the region's healthier CS industry/opportunity environments with two *Computer Science Zone* top 50 cities (Kansas City and St. Louis) within its borders and one other (Overland Park, KS) just across the western state line.

To be fair it should be noted that policies advanced by Code.org are relatively new -- so states that have adopted them have only recently done so. Case in point, New Jersey was one the earliest adopters of any CS educational policy (i.e., establish rigorous K-12 CS standards in 2014) (Code.org, 2018a). Many other states have adopted these sorts of policies but most have adopted them only after 2017. Therefore, it will be some time before the success of these measures can be evaluated in a serious way but emerging research indicates these sorts of polices may lead to desirable outcomes.

Lee (2015) examined the extent to which taking more CS courses in high school predicts students' science technology, engineering and mathematics (STEM) major choices in U.S. postsecondary institutions. Controlling for key demographic characteristics (i.e., gender, socioeconomic status, and racial background), Lee utilized a nationally representative sample of young adults in the U.S. who were 12th graders in 2004. He then compared the results to well-documented predictors of students' STEM major choices (e.g., credits earned in math and science courses as well as ACT math scores).

Logistic regression analysis of the data suggested that students who took more computer science (CS) courses were significantly more likely to choose STEM majors in both four-year and two-year postsecondary institutions. Moreover, regardless of the type of postsecondary institution (two or four-year), Lee found that taking more CS courses played a significant role in choosing STEM majors. In addition, the inquiry suggested the effects of CS education on student STEM major selection were equally as strong as the effects of math and science education. Lee concluded that promoting the quality of CS education is just as important in motivating students to pursue STEM education and career choices at the secondary level as are math and science education.

The Lee (2015) study and its findings are important because it is one of the only well designed, large data set efforts, suggesting the promotion of CS education (as Code.org policies do) not only benefits CS, but also appears to encourage students to choose to pursue other STEM related majors in college. That being stated, the study suggests nothing about the numbers of students that ultimately choose to join the CS workforce.

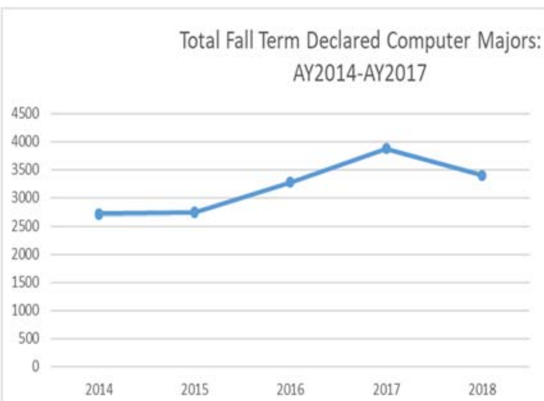
Specific results of Code.org polices from states surrounding Missouri must be categorized as emerging at this point in time because they have been in effect for relatively short periods of time. In 2015, HB 1183 enacted the nine Code.org CS policies in Arkansas. Table 2 contains information on Arkansas computer science majors disaggregated by credential/degree type collected from 2014-2015 through 2017-2018 for all public two- and four-year Arkansas institutions. One area of interest is that the number of CS majors pursuing bachelor’s degrees has increased while the number of individuals pursuing other sub-baccalaureate credentials/degrees has decreased over the same period. The data also indicate that in some categories, the number of students enrolled in particular CS degree programs are up (e.g., bachelors, masters and doctoral degrees) while all others are trending down (e.g., certificate of proficiency, technical certificates, and associate degrees).

Table 2. Fall Term Majors in Arkansas Computer Degree Programs

Degree Level	2014	2015	2016	2017	2018
Certificate of Proficiency	45	41	32	28	36
Technical Certificate	112	98	69	44	47
Associate Degree	1,210	1,024	950	823	852
Advanced Certificate	4	3	0	1	2
Bachelor's Degree	1,240	1,383	1,497	1,681	1,715
Master's Degree	98	179	708	1,212	700
Doctoral Degree	9	16	22	84	53
Total	**2,718**	**2,744**	**3,278**	**3,873**	**3,405**

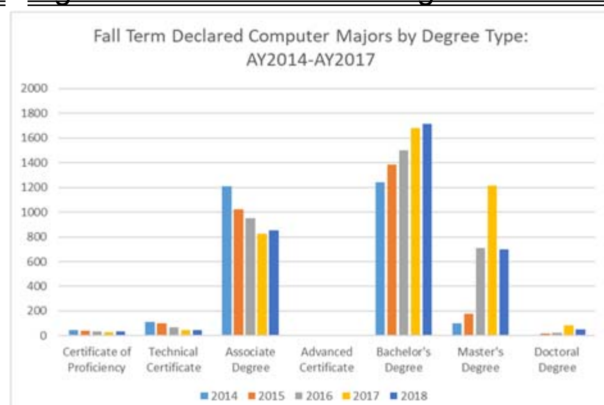
NOTE: Majors included in this data are all majors for the appropriate year listed in the degree codes tab

Figure 10. Arkansas CS Majors 2014-17



Source: AR Department of Higher Education

Figure 11. Arkansas CS Degrees 2014-17



Source: AR Department of Higher Education

The Arkansas Department of Higher Education explains the large spike in master's degrees was due to a large influx of international students. The Department advises that spike has now flattened.

In accordance with what was suggested previously -- specifically that states are adopting these policies without much evidence to suggest that doing so will actually be beneficial -- the Arkansas Department of Higher Education commented that the effects of the legislation will not be fully felt in higher education for a few more years because the students impacted are still in high school. Therefore, no conclusions on the effects of these policies on higher education enrollments or the workforce in Arkansas can be drawn. Nonetheless an assertion that can fairly be offered is that the production of CS related credentials in Arkansas has remained relatively unchanged over the last five years.

Leaders in technology and computer science (CS) like California, Texas, and Florida had substantial and vibrant industries long before the adoption of any K-12 educational policies to promote or require CS course work in their public schools. In fact, California – the state with the most *Computer Science Zone Top 50 Cities and Towns With the Most Computer-Related Jobs* – allows individual school districts to decide whether CS can satisfy a core graduation requirement and has adopted only three of Code.org's suggested policies -- two of which since 2016. This is interesting in light of data that suggests states are now in something of an "arms race" to enact computer science educational policies (see Figure 4. State Tracking – Nine Code.org CS Polices) while very little evidence regarding the effectiveness of those policies is currently available. Moreover, it stands to reason that if every state enacts the sorts of policies suggested by Code.org, and Figure 4 indicates that most are indeed doing so, it might be safe to assume that there will be little change in the ranks of regional leaders because no one state will realize any substantial competitive advantage. This may in fact materialize because as we will see, the availability of a suitable workforce -- which these educational policies are designed to produce -- is an important but nonetheless single aspect of a complicated web of interconnected elements that combine to create a vibrant business environment.

REGIONAL DEVELOPMENT -- CLUSTER THEORY

Scholars have approached understanding economic and regional development issues in a great number of ways which are far beyond the scope of this report. However, due to its relatively intuitive nature, an approach that has gained favor is to view economic/regional development through the lens suggested by cluster theory.

Porter's Cluster Theory

Proponents of the regional concept of economic development believe that every region in the country has the potential to become an innovation center for *some industry* – but only a handful of regions have fully developed the required support systems for innovation based growth in *specific industries*. Harvard Business School professor Michael Porter (1990, p. 78) defines clusters as "geographic concentrations of interconnected companies and institutions in a particular field." The theory holds that concentrating particular firms, businesses, or industries in specific areas or regions creates competitive advantages including:

1. Less competition and thus higher profits.
2. Steady presence of a reliable fairly static customer base guarantees business and steady cash flow/profits.
3. Low production costs due to the steady presence of suppliers.
4. Concentration in particular geographic location promotes and creates more close relationships that produce new industry knowledge which creates better business.

More specifically Porter (1998) suggested clusters:

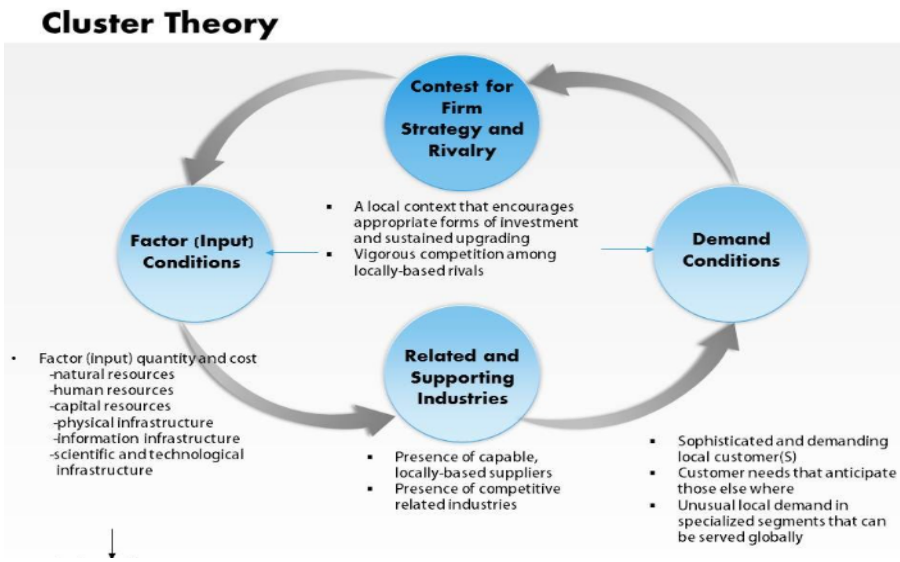
- Link industries and other entities, such as suppliers of specialized inputs, machinery services, and specialized infrastructure.
- Create/encourage/promote distribution networks and customers, producers of complementary goods and services, and companies related by skills, technologies, or common inputs.
- Often are linked by related institutions including research organizations, universities, standard-setting organizations, and others.

Clusters contain multiple relationship dimensions, including geography, social distance, technology, and production flows but it is important to note that not all operate in all dimensions – so for every cluster identified exceptions can be noted.

Cortright (2006) suggests that clustering is mainly concerned with physical proximity – or that businesses that are closer to one another have advantages that are unavailable to businesses that are farther away. The concept of close proximity between members of the cluster suggests specific advantages including technological distance (similarity of the technologies that the businesses utilize), skill or occupational distance (similarity of workers), market distance (similar or connected customers), and social distance (interactions between management and employees of related businesses).

Porter (1998) describes industry clusters as the product of four factors he calls the “diamond of competitive advantage”: factor conditions, demand conditions, related and supporting industries, and firm strategy, structure, and rivalry (see Figure 12). Factor conditions include the local production elements from which all cluster business can draw (e.g., skilled labor force, specialized infrastructure, and educational institutions). Factor inputs must improve in efficiency, quality, and (ultimately) specialization to increase productivity (Porter, 2000). Porter asserted that if specialized factor conditions are available at a single location only -- it is less likely that the same set of conditions will be available elsewhere. Thus, Porter theorized that demand for services and products from firms in this specific cluster will rise because no other location provides the same set of services and products.

Figure 12. Porter's Diamond of Competitive Advantage



Members of clusters stay on the cutting edge as a result of continuous pressure to innovate. Porter theorized that the presence of sophisticated and demanding local customers cause this pressure to innovate and thus help cluster businesses to compete more successfully in global markets. Furthermore, locally based suppliers and competitive related industries create a network called related and supporting industries. The collaboration, cooperation, and support that occurs between cluster businesses firms and their network of suppliers also promotes innovation due to knowledge exchanges (Porter, 2000).

With the basics of cluster theory as a backdrop, it becomes clear why larger population centers are more likely to develop and maintain successful clusters in a variety of industries. Larger population centers are far more likely to have the factor inputs, related and supporting industries, demand conditions, and context for continuous upgrading and vigorous local competition. This suggests that the emergence of clusters in less densely populated rural areas -- especially computer science and technology clusters that are dependent on a highly educated and skilled workforces, distribution networks and sophisticated customers, producers of complementary goods and services, and companies related by skills, technologies, or common inputs, and supporting organizations including research organizations and universities – are not very likely. Figures 6, 7, and 8 suggest this is so because they show that concentrations of CS opportunities are generally sparse in rural areas. Additionally, the emergence of CS/technology clusters in rural areas are not particularly likely because, as Porter theorized, when specialized factor conditions are available at a single location only (metropolitan areas) -- it is less likely that the same set of conditions will be available elsewhere (rural area). As was mentioned previously, not all clusters operate in all dimensions so exceptions do exist. However, there are no CS clusters that can truly be characterized as existing in a rural area. Examples of leading computer science clusters in high and *relatively* low population centers are described below.

Leading Computer Science/Technology Clusters

Atlanta (aka the Silicon Peach in reference to its many high-tech companies) is ranked third in *Computer Science Zone's 50 Cities and Towns with the Most Computer-Related Jobs.* Atlanta has an estimated population of 447,800, the Atlanta-Sandy Springs-Marietta urban area has 4.975 million, the Atlanta-Sandy Springs-Roswell MSA/metro area 5.523 million, and the 39-county Atlanta-Athens-Clarke-Sandy Springs area has 6.162 million. Metro Atlanta was ranked sixth fastest-growing city for information technology jobs in an April 2012 Forbes list and the area is said to have the fourth-highest number of jobs in this sector.

The Atlanta area has dozens of universities, colleges and other institutions. Some of the universities in Atlanta city limits include Georgia Institute of Technology (Georgia Tech), Georgia State University, American Intercontinental University, Clark Atlanta University and Emory University. Attractive aspects of the Atlanta region is a moderate climate, a thriving arts community with a vibrant TV and movie industry. Atlanta has hosted several Super Bowls as well as the 1996 Summer Olympics and the Atlanta Braves, Atlanta Hawks, and Atlanta Falcons call the city home.

Information technology, logistics, business services, professional services, media operations (particularly cable TV), film and television are among Atlanta's top industries. Top employers include AT&T Mobility, UPS, Coca-Cola Company, Home Depot, Delta Air Lines, CNN, TBS, Cox Enterprises and the Weather Channel. More than 75 percent of Fortune 1000 companies have offices in the metro Atlanta area.

Even without a full blown cluster analysis, it is clear that Atlanta has the factor conditions (e.g., skilled labor force (presence of educational opportunity), specialized infrastructure (e.g., Hartsfield–Jackson International Airport), and educational institutions (e.g., dozens of universities, colleges) required to support a vigorous CS cluster/community. In addition, by virtue of its population and the presence of many Fortune 1000 companies, Atlanta would logically have the sophisticated and demanding local customer base to cause pressure for innovation. Furthermore, because Atlanta has many high-tech companies existing in close proximity to one another, the primary requisite for cluster emergence, it would certainly seem that an environment where locally based suppliers and competitive related industries (e.g., film and television companies, Delta Airlines) can create supportive networks of collaboration, and cooperation to promote innovation due to knowledge exchanges. For these reasons, it isn't any surprise that Atlanta is ranked number three in *Computer Science Zone's Top 50 Cities.*

While the population of Palo Alto, California is around 67,000, it can't really be characterized as small or rural. Palo Alto is part of the legendary Silicon Valley (which in turn is part of the San Francisco Bay Area) and has been instrumental to many tech startups. This has made Palo Alto the number one rated city in *Computer Science Zone's 50 Cities and Towns With the Most Computer-Related Jobs*. Palo Alto is in close proximity to the census-designated area known as Stanford, California -- home to Stanford University where many technology companies originated as college projects.

Palo Alto's employment environment is rated A+, education opportunities/institutions - A+, housing - A+. It is however very expensive to live in Palo Alto. Due to its high wage environment, desirable climate, and geographic location, Palo Alto gets an F for cost of living. Higher education institutions close to Palo Alto are Stanford University and Palo Alto University. Over 7,000 businesses call Palo Alto home including several leading CS/technology companies including: Amazon.com's A9.com, Hewlett-Packard, IDEO, Mashable, Ning, Palantir, Palo Alto Research Center, Tesla Motors, Tibco Software, VMWare, Xerox, AOL, Dell, Groupon, Nokia Research Center, Skype and several others.

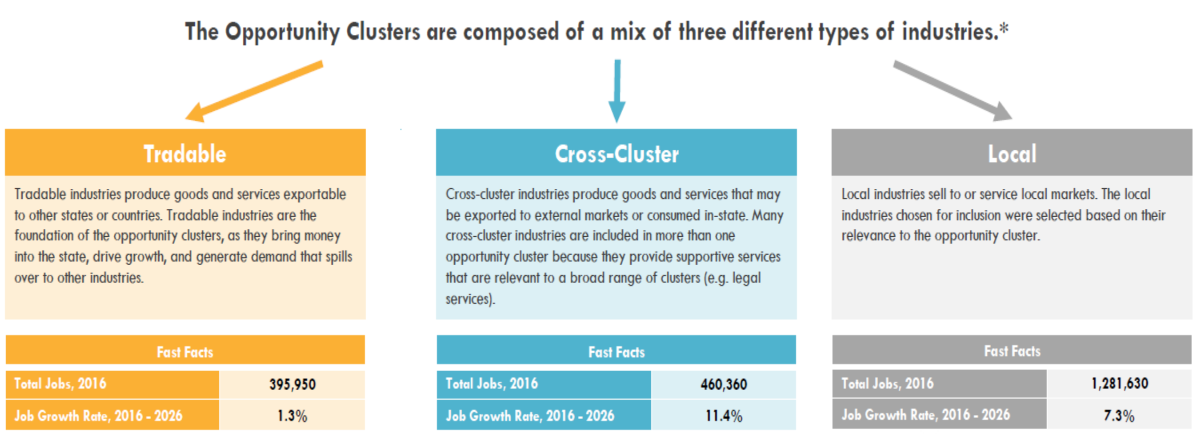
When considering Palo Alto's technology/CS cluster in relation to Atlanta's it becomes clear that while each contains multiple cluster relationship characteristics (e.g., geography, social distance, technology, production flows) they certainly do not operate in the all of the same dimensions. While Palo Alto doesn't possess the population and infrastructure advantages or the number of educational institutions Atlanta enjoys, it is nonetheless the number one ranked city/region with many of the most prominent CS related companies on the globe. Furthermore, while San Francisco is close by, Palo Alto doesn't have the cultural/entertainment attractions (e.g., professional sports, film and television) that Atlanta offers. However, as Cortright (2006) suggests, if clustering is mainly concerned with physical proximity then Palo Alto's wealth of industry leading CS/technology companies supported by world class educational institutions and a highly educated workforce seems to support that contention.

Missouri Opportunity Clusters

The concept of clusters assumes a central role in the 2018 Talent for Tomorrow initiative, a Hawthorn Foundation, Missouri Department of Economic Development and Missouri Department of Higher Education venture. Talent for Tomorrow (TFT) identified “opportunity clusters” in which the report asserts Missouri has a regional advantage by exploring the impact of global megatrends on the Missouri economy and identifying particularly strong “tradable Missouri industries” (i.e., those that produce exportable goods and services). The report identified jobs needed to support the clusters and determined which of those jobs have the best long-term prospects based on the likelihood of automation and wages (Talent for Tomorrow, 2018).

Talent for Tomorrow (2018) sought to identify groups of industries that share supply chains or inputs such as workers, information, or goods to capture the linkages between those industries. Industries meeting these criteria were grouped into seven “opportunity clusters” (i.e., aerospace and defense, agribusiness, automotive and transportation, energy solutions, entertainment and media, financial services, and healthcare and life sciences) (see Figure 13). Talent for Tomorrow (TFT) also identified three “cross-clusters” (i.e., education, health care, and manufacturing) that support all or nearly all of the opportunity clusters (See Figure 13).

Figure 13. Talent for Tomorrow Opportunity Cluster Composition



Source: Talent for Tomorrow 2018

While many of the identified industries certainly have CS/Information technology at their cores, CS and IT (see Figure 14) were not specifically identified by TFT as Missouri opportunity clusters.

Figure 14. Talent for Tomorrow Opportunity Clusters

	Missouri	Aerospace & Defense	Agribusiness	Automotive & Transportation	Energy Solutions	Entertainment & Media	Financial Services	Life Sciences	Cross-Sector Manufacturing
Employment									
Employment, 2016	3,009,181	782,372	1,112,213	1,034,371	815,332	1,237,132	780,521	984,759	827,280
% of MO Employment	100%	26%	37%	34%	27%	41%	26%	33%	27%
Job Growth, 2016 – 2026*	▲7.3%	▲8.6%	▲8.2%	▲7.3%	▲9.4%	▲7.1%	▲10.4%	▲11.0%	▲8.5%

Source: Talent for Tomorrow 2018

Talent for Tomorrow also identified top jobs within particular regions and opportunity clusters. The inquiry found significant numbers of CS jobs in the Central region (Columbia, Jefferson City, Rolla) and in accord with *Computer Science Zone 50 Cities and Towns With the Most Computer-Related Jobs*, in the Kansas City and St. Louis regions.

St. Louis ranks 28th in the *Computer Science Zone 50 Cities and Towns With the Most Computer-Related Jobs*. The 2010 Census indicated the St. Louis population was 319,300. In 2010, the urban area was 2.151 million, the MSA/metro area 2.81 million, and the combined statistical area (CSA) 2.906 million. The St. Louis livability index is 76 (employment - C, education - B+, housing - B, cost of living - B). There are 16 institutions of higher education in the Higher Education Consortium of Metropolitan St. Louis including Harris Stowe State University, St. Louis University, University of Missouri-St. Louis, and Washington University. *Computer Science Zone* largely agreed with the TFT (2018) opportunity cluster findings indicating that top St. Louis industries are transportation of goods, manufacturing, tourism, healthcare, biotech, and life science.

Scottrade, Wells Fargo Advisors, MasterCard, TD Ameritrade, BMO Harris Bank, United Van Lines, Mayflower Transit, Anheuser-Busch, McDonnell Douglas, Sigma Aldritch call St. Louis home. St. Louis's professional sports teams are the St. Louis Cardinals and the St. Louis Blues. Figure 15 indicates that the St. Louis region generates roughly 1,650 openings per year in various CS occupations.

Figure 15. St. Louis Top 25 Jobs – Talent for Tomorrow

	Annual Job Openings	Automation Risk	Median Wage, 2017	Impact Score
Longer-Term Training Required				
Registered Nurses	2218	Low	$58,606	252.88
General and Operations Managers	1124	Low	$69,714	149.82
Software Developers, Applications	546	Low	$70,058	73.10
Financial Managers	352	Low	$102,860	67.09
Accountants and Auditors	910	High	$56,831	60.54
Business Operations Specialists, All Other	477	Low	$64,573	59.25
Computer Systems Analysts	439	Low	$68,699	57.71
Elementary School Teachers, Except Special Education	705	Low	$39,530	57.09
Sales Managers	238	Low	$115,293	50.53
Computer and Info Systems Managers	238	Low	$112,368	49.20
Secondary School Teachers, Except Special and Career/Technical Education	441	Low	$42,076	37.62
Teachers and Instructors, All Other	347	Low	$54,575	37.14
Human Resources Specialists	384	Low	$47,335	36.32
Management Analysts	290	Low	$62,558	35.00
Medical and Health Services Managers	207	Low	$89,873	34.83
Market Research Analysts and Marketing Specialists	567	High	$48,129	32.62
Middle School Teachers, Except Special and Career/Technical Education	336	Low	$46,024	31.01
Marketing Managers	115	Low	$143,898	29.99
Software Developers, Systems Software	178	Low	$87,077	29.08
Network and Computer Systems Administrators	241	Low	$60,438	28.20
Nurse Practitioners	151	Low	$92,287	25.98
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	226	Low	$74,901	25.66
Industrial Engineers	188	Low	$71,309	25.58
Securities, Commodities, and Financial Services Sales Agents	336	Low	$35,969	25.13
Lawyers	196	Low	$64,597	24.39

Source: Talent for Tomorrow 2018

Kansas City's 2010 population was 459,800. The urban population was 1.519 million, population in the metro/MSA area was 2.340 million, and the combined statistical area (CSA) (which includes MO-KS MSA and the Kansas City-Overland Park MO-KS CSA regions) is 2.394 million. Professional sports teams in Kansas City are the Royals, Kansas City Chiefs, and Sporting Kansas City.

Figure 16. Kansas City Top 25 Jobs – Talent for Tomorrow

	Annual Job Openings	Automation Risk	Median Wage, 2017	Impact Score
Longer-Term Training Required				
Registered Nurses	804	Low	$58,606	127.88
General and Operations Managers	680	Low	$69,714	127.06
Software Developers, Applications	595	Low	$70,058	111.73
Elementary School Teachers, Except Special Education	515	Low	$39,530	57.29
Accountants and Auditors	599	High	$56,831	55.54
Computer and Information Systems Managers	188	Low	$112,368	55.09
Computer Systems Analysts	274	Low	$68,699	50.52
Financial Managers	158	Low	$102,860	42.51
Business Operations Specialists, All Other	218	Low	$64,573	37.90
Secondary School Teachers, Except Special and Career/Technical Education	318	Low	$42,076	37.45
Sales Managers	101	Low	$115,293	30.35
Lawyers	169	Low	$64,597	29.39
Substitute Teachers	371	Low	$25,429	28.19
Software Developers, Systems Software	121	Low	$87,077	27.77
Management Analysts	163	Low	$62,558	27.51
Marketing Managers	70	Low	$143,898	26.07
Human Resources Specialists	184	Low	$47,335	24.02
Middle School Teachers, Except Special and Career/Technical Education	183	Low	$46,024	23.33
Market Research Analysts and Marketing Specialists	272	High	$48,129	21.71
Education Administrators, Elementary and Secondary School	107	Low	$76,343	21.71
Medical and Health Services Managers	91	Low	$89,873	21.59
Electrical Engineers	85	Low	$94,132	21.09
Network and Computer Systems Administrators	122	Low	$60,438	19.96
Civil Engineers	88	Low	$67,428	15.89
Computer Occupations, All Other	96	Not measured	$72,508	14.95

Source: Talent for Tomorrow 2018

Numerous colleges and universities are available to the people of the region including the University of Missouri-Kansas City, Rockhurst University, Kansas City University of Medicine and Biosciences, Avila University, Park University, and Baker University. Top employers include the federal government (including the IRS and nearly 150 agencies in total), Honeywell, DST Systems, UPS, Home Depot, Hallmark, Sprint, and Black & Veatch. Overland Park has actively been seeking tech companies (e.g., Netsmart Technologies 2011).

The top industries cited by *Computer Science Zone* align with those identified by Talent for Tomorrow (2018). They are educational services, health care, and social assistance. The Kansas City region creates almost 1,400 computer science/information technology related jobs per year with 595 positions for software developers, analytics and 188 positions for computer systems managers each carrying salaries of nearly 100,000 dollars per year.

The top cross cluster industries in the Central region (Columbia, Jefferson City, Rolla) include educational services; professional, scientific, and technical services; management of companies and enterprises; and data processing, hosting and related services. Columbia's economy is dominated by education, healthcare, and the insurance industry. Government jobs are also common either in Columbia or in

Figure 17. Central Region Top 25 Jobs – Talent for Tomorrow

	Annual Job Openings	Automation Risk	Median Wage, 2017	Impact Score
Longer-Term Training Required				
Registered Nurses	5,175	Low	$60,523	59.35
General and Operations Managers	2,940	Low	$70,632	56.49
Secondary School Teachers, Except Special and Career/Technical Education	4,438	Low	$42,569	42.13
Elementary School Teachers, Except Special Education	2,159	Low	$40,268	20.01
Business Operations Specialists, All Other	1,015	Low	$53,942	16.26
Financial Managers	536	Low	$95,600	14.83
Educational, Guidance, School, and Vocational Counselors	950	Low	$43,122	14.02
Education Administrators, Elementary and Secondary School	717	Low	$76,140	12.55
Loan Officers	1,092	High	$59,736	11.98
Accountants and Auditors	1,257	High	$50,564	11.83
Medical and Health Services Managers	519	Low	$78,956	11.31
Middle School Teachers, Except Special and Career/Technical Education	1,064	Low	$46,458	11.23
Computer Systems Analysts	629	Low	$56,492	10.12
Education Administrators, Postsecondary	391	Low	$106,363	9.72
Human Resources Specialists	599	Low	$49,272	9.39
Public Relations Specialists	518	Low	$49,676	8.51
Nurse Practitioners	351	Low	$90,885	8.28
Software Developers, Applications	336	Low	$75,268	8.12
Network and Computer Systems Administrators	579	Low	$60,456	7.44
Physicians and Surgeons, All Other	311	Low	$199,141	6.82
Chief Executives	339	Low	$108,508	6.71
Coaches and Scouts	435	Low	$31,589	6.22
Nurse Anesthetists	196	Low	$156,926	5.50
Instructional Coordinators	418	Low	$45,337	5.49
Lawyers	383	Low	$70,633	5.31

Source: Talent for Tomorrow 2018

Jefferson City. The Columbia Regional Airport and the Missouri River Port of Rocheport connect the region with trade and transportation.

The Central region is home to the flagship campus of the University of Missouri System, Missouri Science and Technology, Lincoln University and several private four year institutions. The Missouri Theatre Center for the Arts and Jesse Auditorium are the region's largest fine arts venues and the True/False Film Festival is held in Columbia. The University of Missouri Tigers provide the sports culture for the region in the absence of major league sports franchises.

Missouri's Central region is not mentioned by *Computer Science Zone* as a top 50 location for CS jobs and it does not have the population of the major metropolitan areas nor the sheer number of CS/technology related businesses in close proximity to one another. Nonetheless, according to Talent for Tomorrow (2018) it generates 1,544 CS related jobs per year.

Cluster Creation/Promotion

In their infancy, clusters attract other firms, venture capital, and associated institutions while spawning spin-offs and imitation business from the initial set of cluster members. Demand advantages, knowledge infrastructure, legislative initiatives, networking, social capital, and the presence of related clusters then drive cluster growth. Clusters mature as part of a climate created by local institutions, supporting infrastructure, and a local culture. In the maturation stage – business consolidations occur between the members in response to a focus on efficiency and economics of scale. Then environmental changes can force clusters to either close or to innovate to rejuvenate (Malmberg & Maskell, 2002). Scholars assert that clusters follow a predictable development pattern, however the literature suggests that the complicated nature of the relationships within clusters indicate they are probably beyond the ability of governments to fully control or create. Belussi and Sedita (2009) have posited that clusters often originate through the founding or location of one or a few firms and Ingstrup and Damgaard (2011) suggest that the parents of clusters are natural production advantages and even -- historical accidents. Governments can however, *encourage* clusters to emerge by planting important seeds.

Based on experience with clusters from around the world, Ketels and Memedovic (2008) offer guidelines for policy designed to encourage cluster emergence. It is important to understand however that the creation of specific industry clusters (e.g., CS clusters) are beyond the ability of policy makers to control.

First, Ketels and Memedovic state that successful cluster policy builds on sound economic policies and sound strategy for elevating competitiveness. The researchers suggest that cluster development should be a part of that strategy -- but it cannot substitute for policy reforms in other arenas (e.g., education, labor markets, and competition law).

Second, and just as pertinent, is that government should be open to support *all clusters that show willingness to cooperate and have existing assets*. Ketels and Memedovic (2008) stress that *policy should not pick winners among clusters or potential clusters*. Instead, government should seek to nurture and reinforce established and emerging clusters that have not yet reached full potential rather than trying to create the clusters it favors. In places that have no clusters it is important to find emerging clusters and identify their business environment strengths and weaknesses (e.g., use similar technology, skills, and factor inputs used by existing clusters).

An important third recommendation is that government should engage as a facilitator and participant, *not as the leader*. The researchers highlight that in the 1990's countries and regions spent billions attempting to create clusters -- especially in 'high-tech' industries. These initiatives were supported by legislation/policy to encourage investment in specialized infrastructure, targeted financial incentives and/or temporary competition protections. Those attempts mostly failed (Ketels and Memedovic, 2008).

Missouri as a National Computer Science Leader

Can regions in Missouri overtake locations like Atlanta or Palo Alto to become national leaders in the number of computer science jobs? In reality, that is exactly what would need to happen for Missouri to become a national leader in the number of computer science jobs. A cursory look at the cities in Missouri that are most likely to accomplish national leadership status indicates that while not impossible -- they would have a long way to go.

Missouri has only two regions that are ranked by *The Computer Science Zone's 50 Cities and Towns with the Most Computer-Related Jobs* (St. Louis, 28 and Kansas City 43) – both in the bottom half. Second, the findings of Talent for Tomorrow (TFT) (2018) indicate that while the Kansas City, Central, and St. Louis regions have significant needs for individuals trained to assume positions in the CS industry, TFT does not specifically identify CS/IT as a Missouri "opportunity cluster." Third, to surpass national leaders in the number of CS related jobs like Palo Alto and the

Atlanta metropolitan area which both enjoy significant advantages in highly educated and skilled workforces, established distribution networks and sophisticated demanding customer bases, the number of CS/technology and Fortune 500 companies related by skills, technologies, and common inputs, as well as world class supporting research organizations and universities -- theory suggests that Missouri regions would need to attract vastly more CS/technology related business to support the evolution of the “diamond of competitive advantage” conditions that Porter (1990, 1998, 2000, 2003) suggested are necessary for cluster development to occur. While these events *could* transpire – because the Talent for Tomorrow (2018) report suggests that Missouri’s business strengths or “opportunity clusters” are in areas other than computer science – they seem unlikely, especially in the near term.

Scholars in cluster theory warn that policymakers should avoid picking winners among clusters or potential clusters. Instead, they suggest nurturing and reinforcing established and emerging clusters rather than trying to create particular clusters. Instead of aspiring to become a national leader *in any particular industry,* including computer science, research suggests that Missouri should support any and all clusters or possible emerging clusters. Missouri clusters and emerging clusters have been identified by the Talent for Tomorrow (TFT) initiative. They are aerospace and defense, agribusiness, automotive and transportation, energy solutions, entertainment and media, financial services, healthcare and life sciences, education, health care, and manufacturing (Talent for Tomorrow, 2018). Porter (1998, 2000) suggests a theory aligned approach for encouraging the aforementioned Missouri opportunity clusters would involve:

- improving overall business environment conditions
- improving workforce skills, capital access, and infrastructure
- streamlining rules and regulations,
- supporting sophisticated local demand.

In sum, cluster theory suggests environments conducive to the vigorous growth of a particular industry or set of related industries requires much more than the presence of an appropriate workforce. Because of their complicated relationships and interconnectedness, it is important for policymakers to realize that initiatives intended to facilitate the emergence of particular industry clusters is an uncertain proposition at best because efforts to create technology clusters have more often than not failed. In fact, Ketels and Memedovic (2008) assert that when government intervention has been credited for the establishment of new clusters, those clusters had favorable locations as well as appropriate business/environmental conditions. In other words, governments have intervened to “create” clusters in places where those clusters would have materialized anyway.

DISCUSSION/RECOMMENDATIONS

This inquiry has explored a wide ranging question: Can Missouri become a national computer science leader? The question has been explored from several theoretical standpoints. The philosophical underpinnings of education’s purpose were first considered. Philosophic perspectives universally suggest occupational preparation is indeed an important – but nonetheless single -- purpose of education. It was also suggested that any part of the schooling experience should integrate with its central societal purpose -- to instill and reinforce a society’s essential values to protect and reproduce the prevailing social order.

With the passage of HB 3, computer science (CS) coursework will be expanded and allowed to count in place of other graduation requirements, thereby elevating the importance of the subject matter both explicitly and implicitly. Elevating CS curriculum aligns with the intellectual and economic (e.g., job preparation, workforce development) purposes of education suggested by deMarrais and LeCompte (1995). The initiative also seems to implicitly reinforce the importance of several of society’s essential cultural values including the importance of becoming a productive self-sufficient citizen in a democratic capitalistic society. In this way, the elevation or emphasis of any curriculum accomplishes dual purposes – it explicitly teaches the subject matter while explicitly and implicitly signaling its societal importance. Alternatively, a subject’s unimportance is implicitly communicated when a subject is either not taught or deemphasized.

The central argument for a broad based liberal arts education has always been to provide students with the requite schema to develop strong ordered intellects which in turn provides the ability to explore, examine, and understand a wide range of ideas and topics. Broad liberal arts educational experiences exercise the mind in various disciplines *to strengthen reasoning and thus the ability to learn*. By using diverse approaches to orient and order thinking skills to address diverse disciplines, students develop the attention, concentration, and persistence skills needed to understand arguments, logic, and lines of reason. This suggests that students who experience a wide range of curriculums covering a wide array of disciplines develop the most valuable of all skills – the ability to learn.

When budgets are tight, or when meeting standardized testing benchmarks in subject matters (e.g., English language arts, mathematics, science) used to inform school accountability systems take precedence, instructional minutes or entire courses more associated with liberal arts (e.g., art, civics, history, physical education, music, and sociology) are often diminished, deemphasized, or eliminated. For decades, the hard sciences have been emphasized over liberal arts in an effort to achieve greater economic competitive advantage. This is apparent in the reporting of mathematics and science scores as the primary indicators of school quality while measures for art, history, literature, music, and physical education are either marginalized or go unreported altogether. This is likely a mistake because while all courses (including computer science courses) contribute to a well-rounded education, the make-up and balance of the entire educational experience makes and remakes society by emphasizing (and by default deemphasizing) particular values, dispositions, traditions, skills, abilities, and cultural expectations. This may mean that emphasis placed on the hard sciences has had the effect of deemphasizing course work more focused on teaching about institutions, traditions, and values which are essential for the protection and reproduction of society.

Courses in art, history, literature, music, and social studies teach students about historical triumphs and defeats as well as about standards of behavior and expectations both in personal and professional cultures and contexts. These subject matters, much more so than instruction in the hard sciences, teach students to interact and empathize with their fellow human beings and to navigate within various societal contexts. They teach students about ethics, morals, rights and responsibilities in their roles as individuals, employees, and U.S. citizens. It was therefore asserted that courses and curriculums more associated with liberal arts are essential to career preparation because they provide students with the *soft skills* (e.g., communication, critical thinking, conscientiousness, self-awareness etc.) cited again and again by business and industry leaders as lacking in students.

A seldom considered phenomena that may be creating headwinds for policies focused on strengthening workforces is that today's young people seem to be far less enamored with capitalism than previous generations – a cornerstone principle of the U.S. economic system. A recent poll conducted by Harvard University indicates that a majority of young people do not support capitalism. The survey questioned young adults aged 18 to 29 and found that 51 percent of respondents do not support capitalism while just 42 percent said they support it (Harvard IOP Spring Poll, 2016). This is not a particularly new phenomenon. In 2011, the Pew Research Center found that people ages 18 to 29 were frustrated with the free-market system. In that poll, 46 percent had positive views of capitalism and 47 percent had negative views. With regard to socialism, 49 percent of the young people in Pew's poll had positive views, and 43 percent had negative views (Heimlich, 2012).

The Harvard poll indicated that 30 percent believe government should play a large role in reducing income inequality and 26 percent said government spending is an effective way to increase economic growth. Forty-eight percent agreed that "basic health insurance is a right for all people and 47 percent agreed with the statement that "Basic necessities, such as food and shelter, are a right and the government should provide to those unable to afford them." To more fully explore attitudes toward capitalism, the director of Harvard polling personally interviewed a group of young participants. The interviewees indicated they perceive capitalism to be unfair because it leaves people behind despite hard work. While much research is needed to determine how these attitudes may actually be manifesting themselves in the day-to-day lives of students, recent significant political and social movements (e.g., democratic socialism, Occupy Wall Street) appear to embody these perceptions.

Because survey evidence seems to suggest that many young people feel capitalism, the foundation of the U.S. economic system, is unfair, it may be logical to believe that they may also be less interested or motivated to participate in the institutions and traditions that support it (e.g., career preparation, self-sufficiency, personal accountability/responsibility). Hence, they may also be less likely to be interested or motivated by economic/educational policies/measures designed to bolster a free-market based capitalistic economy. In the end, it may be that because many young people are less supportive of capitalism, and possibly more open to arrangements that would provide the essentials of living -- they may be less motivated and therefore less interested in acquiring the knowledge and necessary skills for successful participation in a system they perceive to be unfair. Labor force participation numbers suggest this is certainly an area for future research.

While no reasons were cited for the trend*, Talent for Tomorrow* (2018) reported that Missourians are participating in the labor force at decreasing rates. From 2007 to 2017, labor force participation in Missouri declined from 67 percent to 64 percent. During the same period, the U.S. participation rate declined from 66 percent to 63 percent – a near mirror image of the decrease observed in Missouri. At the same time, research finding that increasing numbers of young people favor socialism and disapprove of capitalism (Harvard IOP Spring Poll, 2016; Heimlich, 2012) seem to correlate with downward workforce participation trends. In alignment with education purpose theory, these sorts of trends may signal that school curriculums are somehow failing to instill, reinforce, and reproduce foundational institutional societal values and orders (e.g., individual participation in a capitalistic democracy). This may partially explain why stubborn workforce shortages have existed and continue to exist in a number of high paying careers and professions -- including fields related to computer science.

Recommendation: *Coursework in computer science can fulfill education's individual and societal purposes. Moreover, computer science curriculum can be part of an enhanced broad-based liberal arts education. Therefore, it is recommended that computer science curriculums be made more available in Missouri schools as HB 3 encourages. However, because curricular modification has the potential to be extremely consequential to the cultural and socializing aspects of schooling, care must be taken to maintain balances between coursework for career, hard sciences, and curriculums more associated with liberal arts going forward.*

Lack of civic/societal awareness or responsibility and decreased abilities to problem solve and innovate among students may be due in part to dwindling liberal arts learning experiences or a systematic de-emphasis of the importance of those experiences. In other words, if educational programs overly emphasize hard science or career curriculums at the expense of liberal arts experiences, philosophic theory suggests students may become detached from larger societal concerns/constructs to such a degree that they may fail to appropriately understand their individual duties and roles and thus fail to properly participate. This could partially explain why students lack the soft skills employers say they need because while students may have trained to do a job, significant percentages may no longer buy into particular societal constructs (e.g., representative democracy, capitalism) that require traditional behaviors (e.g., soft skills) for successful participation. Thus proposals to replace or diminish foundational coursework with curriculums aimed toward particular careers or industries should be carefully considered.

In support of computer science and other career oriented curriculums, and in line with liberal arts education theory, it is recommended that liberals arts curriculums, particularly those in American history, American free market economic history/theory, and American civics be reexamined for content and improved to augment student understanding of the context and importance of individual career participation within a democratic capitalistic society.

Statistics presented in this study strongly suggest that Missouri lacks the capacity in terms of number of computer science (CS) educational courses/programs/teachers to produce the number of qualified candidates needed by the state's CS employers. Sixty-nine Missouri schools (21 percent of schools with general advanced placement (AP) programs) offered an AP computer science (CS) course in 2016-2017 (22 more than the previous year). Data also indicates that students take fewer AP exams in computer science than in any other STEM subject area. In 2017, 631 exams were taken in advanced placement computer science courses by high school students in Missouri (Code.org, 2018). Missouri has over 11,000 open CS related jobs per year with an average salary of $82,000 while its institutions of higher education produced only 1,138 computer science graduates in 2015.

Statistics such as these indicate the CS industry needs, at a minimum, ten times more trained candidates than are now being produced to fill open CS jobs in the state. Considering Missouri produced only one qualified CS teacher in 2016, that situation will probably persist and more likely worsen in the short term because even if a sufficient number of students choose to pursue CS educational/occupational pathways -- not enough courses or teachers currently exist to support them.

Missouri is not the only state facing this set of circumstances. In fact, the state of CS education in Missouri mirrors that of most other states. For example, California, a much more populous state than Missouri and the state with the most numerous CS jobs, produced 4,029 computer science graduates in 2015. Only 580 California schools (25 percent of schools with AP programs) offered any AP Computer Science course at all in 2016-2017 (210 more schools than the previous year). Importantly, and like most other states, California universities did not graduate a single new CS teacher in 2016 (Code.org, 2018c). Missouri's southern neighbor Arkansas, a state that has recently adopted all nine Code.org policies while having relatively low CS career opportunities, produced 328 computer science graduates in 2015. Fifty Arkansas schools (16 percent of schools with AP programs) offered AP CS courses in 2016-2017 (23 more schools than 2015-2016) and, as was the case in most states, Arkansas universities did not graduate a single new teacher prepared to teach computer science in 2016 (Code.org, 2018c).

WE saw that many states are in the process of enacting a host of policies suggested by Code.org in an effort to improve the state of CS education and to address workforce shortages. They are:

1. Create a state plan for K-12 computer science
2. Define computer science and establish rigorous K-12 computer science standards
3. Allocate funding for rigorous computer science teacher professional learning and course support
4. Implement clear certification pathways for computer science teachers
5. Create programs at institutions of higher education to offer computer science to preservice teachers

6. Establish dedicated computer science positions in state and local education agencies
7. Require that all secondary schools offer computer science with appropriate implementation timelines
8. Allow computer science to satisfy a core graduation requirement
9. Allow computer science to satisfy an admission requirement at institutions of higher education

Since HB 3 (2018) has become law, four of these policy suggestions (policies 2, 3, 4, and 8) will soon be implemented in Missouri.

On average the top five states for CS related jobs have adopted more of the nine Code.org suggested policies than Missouri and its bordering states. It was shown that among the top five states for the most computer science job opportunities, Ohio adopted the lowest number of policies (4 with one in progress) and Virginia adopted the most (7) (Code.org, 2018). All five of the top five states have implemented clear certification pathways for computer science teachers (policy 4) and, all -- with the exception of California, which leaves the decision to individual school districts -- allow CS to satisfy a core graduation requirement (policy 8). These two policies (i.e., 4 and 8) were the most popular among the group of states that include Missouri and its bordering states as well as among the 50 states as a whole.

Interestingly, Arkansas -- a state with relatively low CS industry opportunity levels -- in an apparent effort to become a CS leader (which cluster theory suggests is not particularly likely), has recently adopted the full slate of Code.org polices even while California – the state with the most cities or regions in *Computer Science Zone's Top 50 Cities and Towns with the Most Computer-Related Jobs* – has adopted only three (with one in progress) -- two of which since 2016. Because California adopted these polices very recently and because California has been a perennial leader in the CS industry, it is hard to argue that California's CS industry leadership has much to do with K-12 education policies. Consequently, It was stated that it will take time to assess the effects of these relatively new polices in any serious way.

So what might Missouri expect after the policies contained in HB 3 are implemented? Emerging statistics suggest that students who are exposed to CS courses are more likely to pursue AP CS classes (Suppe, 2018). USA Today recently reported that because more students have been exposed to CS courses, 135,992 U.S. students took AP computer science exams in 2018, representing a 31 percent increase from 2017. African-American students taking AP CS courses rose 44 percent to 7,301, Hispanic and Latino participation increased 41 percent to 20,954, female participation rose 39 percent to 38,195, and the number of rural students taking AP CS exams increased by 42 percent to 14,184 (Suppe, 2018). These statistics are encouraging because they suggest that access to CS classes is expanding the number of students taking STEM coursework. Lee (2015) suggested that students who took more computer science (CS) courses were significantly more likely to choose STEM majors in both four-year and two-year postsecondary institutions. Lee found that taking more CS courses played a significant role in choosing STEM majors. In addition, the inquiry suggested the effects of CS education on student STEM major selection were equally as strong as the effects of math and science education. Lee's study concluded that promoting the quality of CS education is just as important in motivating students to pursue STEM education and career choices at the secondary level as are math and science education.

Taken together, the early evidence suggests that policy approaches, like those suggested by Code.org and contained in HB 3, inspire increased student interest/participation in taking AP CS coursework and pursuing STEM education and STEM career choices. However, while increased levels of interest and participation in CS coursework and majors would logically lead to more people joining the CS workforce, this inquiry did not uncover research indicating that is the case. This lack of research evidence is likely due to the newness of these policies which suggests that states are adopting these polices based on their perceived potential -- and not on actual outcomes. This is concerning because a race has developed between states to adopt these sorts of policies even while the benefits -- and more importantly the unintended consequences -- have yet to fully materialize.

For decades, policy efforts aimed at increasing the numbers of science, technology, engineering and mathematics (STEM) related college graduates have, by and large, resulted in insignificant improvement. The heart of this problem may be because policy advocates/makers often pursue more mature and pragmatic purposes (e.g., economic development, job creation) by using levers they control (e.g., state economic/education/revenue agencies/policies) while mostly overlooking the attitudes, aspirations, and developmental stage of the target audience -- students. Unfortunately, young people aren't often motivated by the same things that motivate adults and many don't appear to be all that interested in STEM careers.

ORC International's Youth CARAVAN survey conducted among a sample of 1,000 13-17 year olds from February 27 to March 6, 2018 highlights how teens' career choices, educational priorities, and economic outlook shifted over a year. Over a year, boys' interest in STEM dropped by 12 percentage points while girls' interest remained unchanged at 11 percent both years – despite intensive efforts to increase interest in STEM and STEM related careers. This finding prompted the senior vice president of brand at Junior Achievement to speculate the declining interest in STEM could be due to children's fear of inadequacy. He cited a January Pew Research Center survey as possible evidence. Among U.S. adults, 52 percent said the main reason young people don't pursue STEM degrees is because they believe those fields are "too hard." This may be one reason why stubborn workforce shortages exist in many STEM related fields like computer science. Unfortunately, research suggests that education initiatives designed to increase interest in *any* occupation may be one of the least impactful tools used to influence the occupational choices of young people.

Research conducted by Ernst & Young (2018) indicate that many factors influence teens' career choices but parental influence and the economy are the major opinion shapers. Students who chose their careers based on parental advice has increased from 19 percent to 28 percent since 2016. In 2017, the percentage of teens who chose careers based on the economy was 52 percent -- it is closer to 40 percent today. Societal influences (e.g., social media) decreased from 15 percent to eight percent and other influencers (e.g., teachers, courses, volunteering and extracurricular activities) had less impact than all others (i.e., less than eight percent) (Ernst & Young, 2018).

If the findings of Ernst & Young (2018) accurately reflect how teen attitudes are shaped, then it appears that education policy may be one of the weakest tools for changing students' career ambitions. Compounding matters is the fact that research finds that changing the most deeply seated prejudices, habits, and beliefs take time and sudden massive behavior changes are very rare (Jorgens, 2016). With this in mind, it is logical to believe that educational initiatives designed to increase interest in particular career paths may have minimal impacts while at the same time impacting curricular balances and consuming finite instruction minutes in schools.

A very consequential potential unintended outcome of attempting to create increased interest in CS and CS related occupations may be that acute shortages in other STEM occupations may be exacerbated. Many believe that CS students share the same basic academic characteristics as those who are attracted to other STEM fields. Therefore, unless the overall pool of students interested in pursuing STEM occupations is substantially increased --the number of students choosing to pursue CS careers might well divert students from other STEM professions (mathematics and science teaching, engineering, nursing) that have experienced and continue to experience serious workforce shortages. Because Talent for Tomorrow (2018) found that STEM educators and nurses are needed in all areas of the state -- and particularly so in rural areas -- diverting STEM students into CS careers which primarily exist in urban areas -- may prove particularly detrimental to workforces in rural Missouri.

The Talent for Tomorrow (2018) initiative found that while there are indeed many thousands of unfilled CS jobs concentrated mainly in three highly populated areas of the state – it also suggested there are far more high paying opportunities in business, education, and nursing in EVERY area of the state. This situation calls into question the idea of creating a new K-12 curriculum designed to ameliorate workforce shortages in a particular industry while K-12 curriculums designed to alleviate even greater workforce shortages in other, arguably more socially impactful occupations, have not been instituted. Moreover, because the computer science industry has been successful in instituting K-12 educational policies that are particularly beneficial to its interests – a precedent has been established that would encourage other industries to pursue similar policies. Considered in relation to the philosophical purposes of education -- this sort of trend may prove problematic. If other commercial enterprises begin to realize success in procuring K-12 curriculums dedicated to their particular interests, it is logical to believe that balances between liberal arts, hard science, and career curriculums may become ever more difficult to achieve and maintain.

Early research on the effects of increased opportunities to take CS in high school suggest increasing enrollments in those courses as well as subsequent CS courses. However, the unintended consequences -- including further dividing the group of students who are able and interested in entering STEM related occupations -- should be closely monitored. This is an important area for future research.

> **Recommendation:** *Because computers and computing permeate all aspects of modern society, opportunities to learn about the subject matter should be available to every Missouri student to fulfill education's multiple purposes. Furthermore, this inquiry has found that Missouri has robust and lucrative computer science opportunity environments in particular areas of the state but lacks the capacity, in terms of number of CS K-12 educational courses/programs to produce the number of qualified candidates needed to meet industry workforce needs. Therefore, Missouri should provide computer science curriculums while allowing for district and student choice/discretion regarding individual goals and local workforce contexts. Emerging evidence suggests that polices like those contained in HB 3 (2018) can expand the pool of students interested in STEM courses and increase the number of students taking CS courses, however unintended consequences including the possible*

exacerbation of perennial shortages in other STEM occupations should be carefully monitored.

The enormity of this inquiry's central question: *Can Missouri become a national leader in computer science* suggested that economic development theory be considered in conjunction with education theory and research. It was shown that, even without the adoption of specific K-12 educational policies to support them, vibrant CS industries have grown and prospered in many areas of the country -- including Missouri. In fact, the CS industry leader California, had no educational policies related to computer science until very recently. So why have states like California, Florida and Texas emerged as CS/technology industry leaders? Moreover, what would it take for Missouri to overtake the front runners to become a national CS leader? While the objective of HB 3 is to create a more robust CS workforce in Missouri, an examination of cluster theory suggested that the availability of a trained workforce is an important, but nonetheless single, part of many elements that are needed for an industry *cluster* to emerge.

Harvard Business School professor Michael Porter (1990, p. 78) defines clusters as "geographic concentrations of interconnected companies and institutions in a particular field." The theory holds that concentrating particular firms, businesses, or industries in specific areas or regions creates competitive advantages. Porter (1998) describes industry clusters as the product of four factors he calls the "diamond of competitive advantage:" factor conditions, demand conditions, related and supporting industries, and firm strategy, structure, and rivalry.

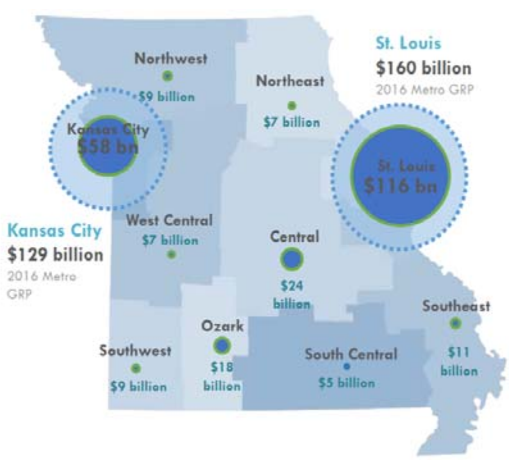
The *Talent for Tomorrow* (TFT) initiative did the important work of identifying existing economic clusters in every region of Missouri. TFT identified groups of industries that share supply chains or inputs such as workers, information, or goods to capture the linkages between those industries. Industries meeting those criteria were grouped into seven "opportunity clusters" identified as aerospace and defense, agribusiness, automotive and transportation, energy solutions, entertainment and media, financial services, healthcare and life sciences) and three "cross-clusters" (i.e., education, health care, and manufacturing) that support all or nearly all of the opportunity clusters.

While many of the industries identified by TFT certainly have strong linkages to CS/information technology, CS and IT were not *specifically* identified by TFT as Missouri opportunity clusters. This is not to say that Missouri does not have regions where vibrant CS clusters might someday emerge. In accord with *Computer Science Zone's 50 Cities and Towns with the Most Computer-Related Jobs*, TFT identified Kansas City and St. Louis as regions having a significant number of CS jobs. In addition, TFT found that the Central region (Columbia, Jefferson City, Rolla) has a significant number of CS job opportunities.

Theory makes clear why major population centers are more likely to have and support clusters. They have the existing population, infrastructure, educational institutions, and an existing community of related business needed for clusters to emerge. So while Missouri has potential for CS clusters to develop in Kansas City, St. Louis, and the Columbia region which research suggests should be supported, the research also suggests that the emergence of CS clusters in other parts of the state – especially in rural areas -- are unlikely.

Scholars have found that initiatives intended to create industry clusters have uncertain outcomes. While billions have been spent and legislation has been enacted in other regions and countries to encourage the emergence of particular clusters (often technology clusters) – it was shown that these efforts have mostly failed. For that reason, researchers have suggested that concentrating on identifying and bolstering already existing clusters that have not reached full potential offers the best chance to produce real economic improvement.

<u>Figure 18. Talent for Tomorrow Regions</u>



Source: Talent for Tomorrow

Ketels and Memedovic (2008) assert that when government intervention has been credited for the establishment of new clusters, those areas had favorable locations as well as the appropriate environmental conditions for business. The researchers therefore stated that governments have intervened to create clusters that probably would have materialized anyway. These facts led the researchers to assert that policy should not pick winners among clusters or potential clusters. Instead, they suggest that government should seek to nurture and reinforce established and emerging clusters by engaging as a facilitator rather than trying to create the clusters it favors as the leader.

According to the Missouri Economic Research and Information Center (MERIC), the 20 occupations with the greatest number of total openings includes four office and administrative support occupations and four food preparation and serving occupations. “Retail salespersons” is the occupation that is expected to have the greatest number of total openings between 2014 and 2024 with over 34,000 total openings expected. While many of these occupations do not pay as well as CS jobs, several on the list are comparable. Registered nurses are paid nearly $60K on average and have been and continue to be in very short supply. The nursing shortage is likely to become more serious as the population ages – arguably creating a much larger concern than a lack of CS professionals. MERIC has projected there will be nearly 10,000 openings for accountants and auditors between 2014 and 2024 who will make on average $72K a year, and an occupation that generally doesn't require high levels of training -- heavy and tractor-trailer truck drivers -- make annual average salaries of $40K.

Even while it has been generally known for years that training for the careers just mentioned would almost certainly pay one substantial dividends – shortages stubbornly persist year-in and year-out – yet core K-12 curricular modifications have not been suggested as an approach to supply those vacancies.

> **Recommendation:** *Missouri is home to two of Computer Science Zone's 50 Cities and Towns with the Most Computer-Related Jobs (St. Louis ranked 28th and Kansas City ranked 43rd). However, for Missouri to become a national leader in the computer science industry, it would need to eclipse or achieve relative parity with the current leaders (i.e., California, Florida, Ohio, Texas, Virginia). To accomplish this, several robust CS industry clusters would need to emerge in Missouri. This inquiry posited that while not impossible, the materialization of several Missouri CS clusters is unlikely in the near term – especially in light of Talent for Tomorrow initiative findings which found that while the Kansas City, Central, and St. Louis regions have significant needs for individuals trained to assume positions in the CS industry – it did not identify CS as a Missouri opportunity cluster.*
>
> *While policies like those suggested by Code.org and contained in HB 3 are intended to promote CS awareness and improve CS skills to expand the CS workforce -- in sum, cluster theory suggests environments conducive to the vigorous growth of a particular industry or set of related industries requires much more than the presence of an appropriate workforce. Stated differently, Missouri should not expect that the presence of a workforce suitable for industry needs will guarantee that a particular industry will emerge. Because most states are adopting very similar educational policies -- all aimed at improving CS education and bolstering CS workforces – it is hard to imagine that any state can achieve a competitive advantage over any other by doing so.*

Because of their complicated relationships and interconnectedness, it is asserted that initiatives intended to facilitate the emergence of any particular industry cluster is an uncertain proposition at best. In fact, researchers have found that efforts to create technology clusters have failed more often than not. Ketels and Memedovic (2008) assert that when government intervention has been credited for the establishment of new clusters, those clusters had favorable locations and appropriate environmental conditions for business. In other words, governments have intervened in situations that likely would have occurred anyway.

Scholars in cluster theory warn that policymakers should avoid picking winners among clusters or potential clusters. Instead, they suggest nurturing and reinforcing established and emerging clusters rather than trying to create the clusters it favors. With this advice in mind, instead of aspiring to become a national leader in any particular industry -- including computer science -- research suggests that Missouri should support any and all existing clusters and possible emerging clusters. Clusters and emerging clusters in Missouri have been identified by the Talent for Tomorrow (TFT) initiative. They are aerospace and defense, agribusiness, automotive and transportation, energy solutions, entertainment and media, financial services, healthcare and life sciences, education, health care, and manufacturing.

Porter (1998, 2000) suggests a theory aligned approach for encouraging the aforementioned Missouri opportunity clusters (and clusters in general). Therefore this effort recommends that Missouri pursue policies designed to:

- *improve overall business environment conditions*
- *improve workforce skills, capital access, and infrastructure*
- *streamline rules and regulations,*
- *support sophisticated local demand*

CONCLUSION

In line with the philosophic purposes of education, this examination has recommended that opportunities for students to learn about computer science be expanded in Missouri not only for individual career and workforce development purposes, but also to improve the condition of liberal arts education in the state. The provisions of HB 3 will almost certainly accomplish these goals. However, it was also cautioned that it is essential to maintain balances between career, hard sciences, and courses more associated with liberal arts if the multiple purposes of education are to be served.

It was suggested that because efforts to modify core K-12 curriculums to address the particular interests of business/industry have been successful, a troubling precedent may have been set. Dedicating curricular minutes (especially compulsory elementary school minutes) to specific industry interests will have consequential implications which may include increased demand for finite instructional minutes and resources as more businesses and industries seek similar accommodations to address workforce issues. It is possible to imagine that the accumulation of compulsory coursework tailored for numerous purposes and careers could impair education's ability to serve some vital societal purposes. This is because when instructional minutes are used for one purpose they cannot be used for another – and those minutes are often taken from courses more associated with liberal arts.

Recently, Supreme Court Justices Neil Gorsuch and Sonia Sotomayor have focused on this concern as it relates to the decline of civics education. During a recent televised CBS news interview Sotomayor said:

> It's been well documented that the partisan discord in our country followed very closely on the heels of schools stopping to teach civic education. One must remember why. It wasn't for an unimportant reason; there was a change of emphasis in the educational system in the country where they wanted to pay more attention to STEM (Civics lessons: Justices Sonia Sotomayor, Neil Gorsuch on promoting education in citizenship, 2018).

Justice Sotomayor's concern echoes points raised here. It was posited that the hard sciences have been emphasized often at the expense of instructional minutes dedicated to liberal arts in an effort to achieve greater economic competitive advantage. This has resulted in courses in subjects like art, civics, history, physical education, music, and sociology being diminished, deemphasized or eliminated. Similar to Justice Sotomayor's concern, theory presented in this inquiry has indicated that if course work dedicated to career and hard science begins to assume too large a role in the overall curriculum at the expense of courses and concepts essential for citizenship and the reproduction of society (e.g., civics, democratic participation, ethics, market economics), unwelcome and unintended consequences may materialize. Evidence suggests this may be occurring.

According to a 2010 study by the National Assessment of Educational Progress, the largest continuing and nationally representative assessment of what U.S. students know and can do, less than a quarter of all 12th-graders were at or above proficient in civics education. On that point, Justice Gorsuch commented:

> Only about 25% of Americans can name the three branches of government. A third of them can't name any branch of government. And 10% believe that Judge Judy is one of our colleagues. It's important if we the people are going to run our government, that we know what it is, how it works, and how we can participate in it" (Civics lessons: Justices Sonia Sotomayor, Neil Gorsuch on promoting education in citizenship, 2018).

Gorsuch may have been eluding to the findings of a 2016 University of Pennsylvania Annenberg Public Policy Center survey which indicated that 26 percent of people can name the three branches of government, a statistically significant decline since 2011, when 38 percent could name all three. The survey also found that 31 percent of respondents could not name any of three branches (Annenberg Public Policy Center, 2016). Theory suggests that one reason for this sort of fundamental ignorance is likely due to a narrowing of broad based learning experiences or a systematic de-emphasis of the importance of curriculums more associated with liberal arts. The absence or de-emphasis of vital sociological schema provided by liberal arts curriculums may be taking a bothersome toll in decreasing the abilities of students to analyze, problem solve, and innovate in all areas of their lives. In line with the concerns of Justices Gorsuch and Sotomayor, this inquiry suggested that if the curriculum begins to overly emphasize the hard sciences and/or individual career or economic pursuits -- students may become detached from the larger social framework to such a degree that they will fail to appropriately contextualize their individual duties and roles within that framework.

We have seen that significant percentages of students no longer buy into foundational societal concepts and constructs. Because increasing percentages of young people seem to be questioning -- or are outright unaware of the bedrock principles of American civics, government, and free market economics -- it was recommended that curriculums more associated with liberal arts be re-examined, reconstituted, re-emphasized, and protected so students' may contextualize their career ambitions/pursuits within the nation's democratic/capitalistic culture, institutions, and traditions. This measure more than any other – may prove invaluable in addressing decades old workforce issues.

Proponents of the regional concept of economic development believe that every region in the country has the potential to become an innovation center for some industry – but only a handful of regions have fully developed the required support systems for innovation based growth in specific industries. This inquiry posited that policy makers should endeavor to create business environments that can encourage and nurture a wide cross section of industries while resisting the urge to select among those it believes should emerge. Lessons learned from command economies like those that existed or still exist in China, Cuba, the former Soviet Union, and

Venezuela reinforce that notion. Therefore, it seems that instead of aspiring to become a national leader in computer science -- or any other specific industry -- Missouri should institute the sorts of policies that would encourage its existing clusters and potential clusters. Fortunately, the Talent for Tomorrow initiative has identified Missouri opportunity clusters that may be encouraged in line with theory.

Finally, curricular modification is a profoundly serious matter which should be undertaken soberly, deliberately, and with careful mindfulness of the intended and possible unintended ramifications. Therefore, the increasingly popular belief that business interests should take over education for the enhancement of economic competitiveness is a mistake. While Aristotle and Plato would have insisted that business and industry have important places at the table -- they would have vigorously disagreed with the notion that those entities should control education. This is so because while business is concerned mainly with profit, education has many purposes -- most having nothing to do with either commerce or profit (e.g., promoting the common good based upon the rational principle of individual and collective justice, the reproduction of societies prevailing values and institutions).

It is important to remember that education for vocation or career only has real meaning when situated within a societal framework that values democracy, capitalism, self-determination, and self-sufficiency. This presentation has suggested that widespread ignorance of the fundamental framework of American life -- or worse teaching that ignores or undermines American foundational principles -- may be creating increasingly hostile environments for any and all workforce development efforts. This is certainly an important area for additional investigation.

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