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“Innovations in STEM Mentoring, Training and Apprenticeships”

Madam Chairwoman and members of the committee, thank you for the opportunity to share what we at Wichita State University are doing to improve STEM education and to more closely tie our educational approach to the skills and economic needs of our metropolitan region and the state of Kansas.

My 40-year career in higher education has taken me from my home state of Ohio to Kansas, Texas, Florida, Massachusetts and North Carolina before returning to Kansas six years ago to become president of Wichita State.

Today I’m sharing the key considerations that led us to re-think how our university approached increasing the quality and quantity of STEM-educated graduates in the workforce. These changes that have attracted international companies to our campus have been made at a university in the very center of America’s heartland, not on the East or West Coast. While Congress will never do so, it is crucial that we not let others write off large sections of our country. Innovations in industries as diverse as aviation, energy and fast food have come from Wichita and can continue to do so. As a university, we are trying very hard to help spur competitiveness, so we have charted a path that is very focused on higher education deeply grounded in applied learning and research.

The passage by Congress of the Bayh-Dole act in 1980 represented a watershed event for higher education and the impact research universities could have on discovery and job growth. Bayh-Dole provided formal recognition of the importance of universities in the technology transfer that would increasingly propel the national and global economy. Thirty-eight years later, the foresight of Bayh-Dole cannot be overstated. It marked a formal beginning of the movement of higher education from the sidelines, as that place where you prepared to “enter the real world,” to higher education becoming one of the major pillars of America’s future prosperity, security and quality of life.

It has become clear since Bayh-Dole that higher education is a crucial component of American economic success and future. University education and research play a pivotal role in our nation’s global competitiveness. We at Wichita State University take this responsibility very seriously and we are fully focused on our role in securing the future. Our strategic plan is straightforward in its vision and direction:

- Our core vision is for Wichita State University is to be internationally recognized as the model for applied learning and research.
- The mission of Wichita State University is to be an essential educational, cultural and economic driver for Kansas and the greater public good.

This vision and mission are inspiring Wichita State University to focus on becoming a new American university driven by the emerging educational needs of a much broader range of students than traditional universities, as well as concentrating on how we can increase global competitiveness for the benefit of the people, the region and the state we serve. In short, we are driven to provide employment

opportunities, prosperity and economic inclusion for those living in southcentral Kansas. The focus of the remainder of my testimony will be on how we are evolving and implementing this mission and vision with specific regard to STEM and the economic competitiveness of our part of the country, as well as some major lessons learned that may be beneficial to this committee and other universities.

One size will never fit all: Education linked to location and economic potential

In the abstract, applied education that incorporates STEM-focused internships, mentorships and apprenticeships clearly improves outcomes for students in these areas. However, when moving beyond the abstract, what to implement and how to implement it becomes much more difficult and nuanced. What might be very appropriate in Huntsville, Alabama may not fit well at all in Wichita, Kansas.

We have learned that programs to improve STEM education have to be designed and implemented with an integrated approach that involves economic analytics, economic structural analysis and on-going feedback and assessment.

From a student's perspective, STEM courses are challenging. He or she needs to be able to see the value, or the work won't be seen as worth the effort. Increasing the number of students in STEM education, and the quality of that education, has to be linked to the student's goals and life interests. In many cases, those interests have more to do with family, community and non-academic pursuits than in long-term, challenging, academic programs. We have to be prepared to answer the student's questions about why education in a STEM field is worth the effort.

At Wichita State, rethinking education began with a contextual analysis

There were four major components to WSU's contextual analysis:

1. Regional economic structural analysis
2. Trade good destination analysis
3. Specific metropolitan economic analysis
4. Blueprint for Regional Economic Growth

These four component analyses were used to establish a context for modifying the university's approach to education, R&D and its relationship with its broader community.

Regional economic structural analysis

A number of studies of the restructuring of both the national and global economies have documented the shift of economic outputs to major metropolitan areas, with these major metros acting as hubs or "economic centroids" for broader regions of production, distribution and economic networking.

Globally, there are approximately 40 such hubs, with 10 of them in the U.S. Third-party analyses of Wichita show that it is a component of one of these 10 "super-regions," part of the "I-35 Corridor." The economic centroid of this super region is increasingly focused on Dallas-Fort Worth and the "Texas Triangle," with cities in Oklahoma, Kansas and western Missouri increasingly tied to that centroid.

Trade good destination analysis

Although services make up a very important part of any economic base, the key driver of new income both for businesses and individuals is the volume and value of goods traded that have their origins within the region. Analyses of Wichita's trade good destinations showed that they largely followed the I-35 corridor, with substantial trade moving to the coasts for export.

Specific metropolitan economic analysis

Bulleted below are some of the most significant findings of the metropolitan economic analysis:

- According to the Brookings Institution, of the largest 100 metropolitan areas:
 - Wichita ranks number 1 in manufacturing jobs as a percent of all jobs, with Wichita having the highest concentration of aerospace manufacturing in the nation.
 - Wichita ranks number 1 in the percentage of jobs involving STEM
- According to the National Science Foundation, Wichita ranks third in the percentage of engineers in the workforce, only exceeded by San Jose and Houston.
- Again, according to Brookings, southcentral Kansas is the most manufacturing specialized region in the U.S, with nearly 18 percent of all jobs in manufacturing.
- Wichita is ranked number three as an “advanced manufacturing hot spot.”

These analyses clearly show that Wichita has, in many ways, a higher stake in effective STEM education than nearly any area in the country. While these general rankings and statements provided a backdrop for next steps, designing effective models to undergird the region’s future prosperity and quality of life required a much finer and detailed analysis than was available to the community and university when we began this work about five years ago. This led to the development, funding and sponsorship by the university of the regional Blueprint for Regional Economic Growth (BREG).

Southcentral Kansas Blueprint for Regional Economic Growth

The final step in our learning process involved bringing in a national firm that specializes in detailed analyses of potential clusters of innovation that can drive the future economy. The university, with the assistance of this firm, looked in detail at potential economic growth sectors; eight were identified. Business leaders and job creators from these sectors were brought together for multiple meetings where they identified needs, stumbling blocks, trends in their area of business and potential for further development. The eight clusters identified were:

- Advanced Manufacturing
- Advanced Materials
- Aerospace
- Agriculture
- Data Services and IT
- Health Care
- Oil and Gas
- Transportation and Logistics

While many of these cluster titles could fit a large number of metropolitan areas, what BREG accomplished was to localize the clusters so that university programs and approaches can increasingly fit the specific situation within this metropolitan region. Based on the needs defined by enterprises in these clusters, coupled with the more general analyses described above, the university began responding by focusing on critical educational and R&D approaches that could improve the competitiveness in several of these clusters.

It should be noted that this is an ongoing process and the university is committed to continuing to extend its capacities to support these crucial clusters. Finally, it should be noted that the process was

considered of sufficient importance that it is now being sponsored and managed by the metropolitan area's primary economic development group, the Greater Wichita Partnership.

In the next sections, lessons learned from responding to this outside-in approach to development of educational approaches to enhancing STEM will be described. The last section also includes a discussion of some opportunities for federal policy and action that could greatly enhance STEM education and promote the competitiveness of the American economy.

STEM education as part of an ecosystem

One of the major issues facing the greater Wichita area has been the continuing outmigration of educated workers and jobs that are being replaced by lower-wage, lower education requirement positions. According to economic analyst James Chung's work for the Wichita Community Foundation, from 2011 to 2013 the typical household leaving the metropolitan area had earned nearly \$71,000 per year, while those moving in averaged approximately \$58,000. The net difference also is associated with a drop in educational requirements for the typical position.

It's not enough to produce more highly capable STEM graduates; the university also needs to take a role in strengthening local companies so that our graduates can be employed here.

So, the university has been systematically working to expand the need for those students, especially in engineering, to remain in the region. The Innovation Campus at Wichita State, the broader partnerships with business, the focus on applied R&D relevant to the region, and increasing support for entrepreneurship and innovation, all are part of the university's overarching approach to increase the competitiveness of the region.

WSU has a long history of supporting the local economic drivers and, in turn, being supported by them. Wichita bills itself as the "air capital of the world" and the aviation industry has been, and will remain, the core advanced manufacturing industry in the region. Partnerships between the university and this industry can be traced back to at least 1948 with the donation to the university of the Walter H. Beech Wind Tunnel. These ongoing partnerships are, from our experience, crucial to development and maintenance of the highest quality STEM education. Because of our continuing interaction with business, we have been able to respond to many pressing needs and to design programs that support both the student's education and the industry's ability to compete. A specific example involves creating and implementing a modified-apprenticeship program designed to have high impact on an existing Wichita industry.

Over the years, one of the most pressing problems that we heard across industries with regard to workforce availability and industrial competitiveness was that, on average, newly graduated engineers took two additional years of training on the job before they could contribute to their companies' profitability.

Testing an apprenticeship model

In response, we created and tested a modified apprenticeship model with one of the advanced manufacturers in the community. Using undergraduate students, we were able to digitize the plans for their most important product with an accuracy, speed and cost not matched by their Asian outsourced engineers. Moreover, because of the quality of the work and the ability of the students to work with their existing technical staff, even though they were not intending to hire, they offered jobs to 35

percent of the students, and 83 percent of the students in the program found employment within the regional labor shed. The remainder found immediate employment outside the regional area or entered graduate school. Most importantly, the company estimated that the apprenticeship model reduced a newly graduate WSU engineer's time to contribute to profitability from two years to less than six months.

What this model has shown is that a well-designed apprenticeship program greatly benefits student learning, and it increases the student's value to employers while providing a major benefit for industry. Instead of leaving the local labor shed, the vast majority of students in this test of the model remained in the region and will continue to contribute to both regional economic competitiveness and the area's quality of life.

Applied learning experiences for all students

Apprenticeships and longer-term internships can be important components of an overall strategy for STEM, but thinking differently about how to educate the students on campus also plays a critical role. That is why WSU's strategic plan calls for all students to have applied learning experiences regardless of major. It also is why the university is experimenting with new programs and program design. One possibly unique example of a program that is designed to increase competitiveness is WSU's Master of Innovation Design. This program is based on the concept of "design thinking" and upon completion of the program, it is expected that the student will have a:

- Portfolio, patent application, process or prototype
- Willingness and ability to experiment with their ideas
- Network of individuals and businesses with whom they can continue to collaborate
- Desire to continue to design solutions to problems they identify

Demand for this program already exceeds available resources, but this type of innovative approach to education linked to technology and other forms of STEM can be a crucial part of the infrastructure and ecosystem that produces new businesses which are globally competitive and can drive demand for STEM educated workers within the metropolitan region. This, then, can be an important element in convincing students to take advantage of STEM education so they can have good careers within their communities.

Directly engaging the private sector to enhance education

Starting a process by involving the private sector, non-governmental organizations and other entities outside the university provides a base from which to begin developing educational programming. Maintaining those relationships is critical. The competitive situation in the broader market requires ongoing interactions with business and the job creators so that the models of STEM education can be modified in ways that continue to promote competitiveness and success that supports the community, region and state.

While universities typically have "business advisory councils" or other regularly scheduled meetings with industry leaders, WSU's approach has been both more in-depth and broader. Of specific note is the strong relationship between industry-sponsored applied R&D and development of the university's Innovation Campus.

As was highlighted above, WSU is a national leader in R&D sponsored by industry. This ongoing, meaningful interaction has allowed the university not just to hear about potential changes in the market, but to have strong, continuous relationships with industry that allow for strong support and development of nuanced educational programs that address the rapidly changing business environment. The origin of the modified apprenticeship model was from the applied R&D at WSU's National Institute for Aviation Research. That is an important step, but it also was the origin of a major restructuring of higher education in the greater Wichita region that will, over time, create new programs and new approaches to STEM education.

Combining traditional and technical education providers

In addition to Wichita State University, our area has been served for decades by Wichita Area Technical College. This college provides GED to associate degree education for the people of Sedgwick County, and it has a long track record of success. But, what became clear several years ago was that the changing nature of STEM education and emerging needs of industry were increasingly difficult to meet either by the technical college or by the university.

This recognition resulted in the two entities affiliating. The technical college will be known as WSU Tech, though its formal name, effective July 1, will be the Campus of Applied Sciences and Technology.

Within WSU itself, there is a substantial reorganization under consideration to create jointly planned bachelor of applied science degree programs with WSU Tech. This would allow much better integration of hands-on technology with traditional STEM education and strengthen both institutions' capacities to respond to emerging business conditions.

The following is an example of an opportunity that combines traditional STEM education with technical education and partnering with industry to serve students and community.

Connecting younger students with engineering education and careers

Many of the major technology-based employers in our region (and throughout the world) use CATIA software as the platform for their engineering applications, from design to manufacturing. To prepare students to enter engineering fields, the university worked with Dassault Systemes to make the software available free of charge to the region's high schools. Demand from schools across the area has been high, and students who take the class come to university with much stronger background in engineering design. And, with WSU Tech, the CATIA program can more readily be linked with pre-collegiate technical programs, early entry technical and STEM programs for high school students, and joint planning and programming in the high schools to encourage students to enter STEM fields at a level that fits their interests and abilities.

This approach of linking high schools and STEM fields is increasingly being integrated into the university, especially in the College of Engineering. The college is growing the number of graduates equipped with the skillset, entrepreneurial mindset and experience to advance economic and technological prosperity, health and well-being.

We aggressively promote engineering and computer science through strategies that include direct outreach to students in elementary schools, middle schools, high schools and community colleges; and indirect outreach by training K-12 teachers in a pre-engineering curriculum and by fostering

relationships with high schools and community colleges to ensure smooth, successful transition into our undergraduate programs. Throughout, we bring industry professionals with us to camp and into schools, to provide vivid accounts of career opportunities. The result is four consecutive years of record numbers of engineering and computer science students graduated.

Although there is a great deal more in which Wichita State University is engaged, this testimony now will turn to challenges that have been faced in implementing these new programs and their potential implications for federal policy that needs to be shaped by Congress if America is to achieve its promise for the future.

Considering Bayh-Dole 2.0: university challenges and federal policy implications

- Universities must maintain service to traditional students while broadening their reach to new populations. Rapid change in the higher education system is forcing different ways of delivering educational content, discovery of new knowledge and connecting to industry to solve problems.

With state and university resources stretched to support existing programming, transition assistance to the new forms of programming would both speed implementation and assist in assuring quality. In part, this transition would be assisted by financial support, but costs could be reduced if federal regulations are eased in other areas so that internal university funds could be repurposed. Reducing the cost of regulations is an ongoing discussion at the federal level and it is an important component of assisting universities in moving to a more modern, connected approach to meeting student needs for a high quality, meaningful education while meeting the challenge of economic competitiveness in critical STEM areas.

- Instituting effective apprenticeship programs require organization, oversight and institutional mentoring, not just mentoring by business. The quality of the student experience in any apprenticeship program or extended internship is crucial to effective implementation. It is not enough to place the student under the “mentorship” of people in private enterprise, since the meaning and use of the student may vary greatly. It is critical, therefore, that any apprenticeship program be designed with specific educational goals directly relevant to the student’s education and that the achievement of those goals be monitored and assessed. This requires a great deal more “one-on-one” time by faculty members and is both an expensive and effective form of education. Assistance in implementing these programs, if they are indeed a high national priority, would be of great value.

One of the lessons of our experience with the fledgling apprenticeship program is that “clustering” apprentices within businesses provides a more meaningful experience for students and better results for the business. This clustering also reduces the cost to the university of supporting the program since a faculty member can supervise the cluster of students more effectively and efficiently than scattered individual students. While this is not always possible or desirable, and especially if the apprenticeship is with a small business, policy that encourages clustering and joint business and university planning would be of great benefit.

- There is very little incentive for faculty members to take on these intensive roles given traditional reward systems in most institutions. University faculty members at research universities are generally rewarded through prestige (the perceived value by colleagues of their research) or by salaries and titles tied to traditional teaching, research and service. Implementing new models of education linked to broader community need could be greatly benefitted by national recognition that focuses specifically on emerging needs, especially related to STEM. A national “fellows” program, grants only available to institutions that are committed to enhancing and enriching education within a context of applied R&D meaningful to their location and mission and similar programs could be of substantial value in signaling to the higher education community that the need to refocus is real, of critical national interest and a high priority.
- There is little to no recognition of the strong ties between regionally relevant applied R&D and effective programs to enhance students’ education through applied learning, apprenticeships or extended internships. WSU’s apprenticeship program has its roots in the university’s research center dedicated to applied R&D. Over the decades of this center’s existence, hundreds of students, especially in engineering, have benefitted from working on real projects of substantial significance to business or the military. Federal policy that strongly encourages this link between education and applied R&D can both enhance the student’s education and produce greater economic competitiveness. At the same time, the ongoing interaction between university researchers, business or government agencies creates an intimate knowledge of the emerging needs of that industry. From our experience, this has produced tremendous results to date. As NSF data have shown, in the area of industry-funded R&D in aviation-related fields, WSU is top in the nation by an order of magnitude.
- Basic science research is critical for the long-term health of the American economy and increasingly federal support for basic research has been concentrated in relatively few dominant research universities. Federal policy does not focus at the doctoral level in terms of support for applied R&D that can be impactful in the short and medium run in creating and sustaining economic competitiveness of many American regions. Perhaps it is time for “Bayh-Dole 2.0” that incentivizes strong STEM doctoral programs that are based in applied R&D partnerships with businesses.

Business has incentives to invest in universities that have strong applied R&D programs in STEM, but the universities themselves have had few such incentives. Focused doctoral student funding for STEM doctoral programs that focus on applied R&D could be of great, immediate assistance. It might be possible, for example, for a federal policy to make these funds available only to institutions that document support for such funding by STEM enterprises and could promote immediate application and increase the future supply of faculty who value, and are trained in, how to effectively conduct applied R&D within a university context.

- It is always difficult to make broad policies that affect hundreds of millions of people, and there is a tendency to “rifle shot” policy. In the case of STEM education, recognizing in policy the importance of how the ecosystem within which the education occurs would be of great benefit.

There is a great deal of literature on why students go to college and how they choose programs and majors. If increasing the number of STEM graduates and the quality of their education are truly national goals, then recognition at the federal level of the importance of the broader ecosystem is crucial. This cannot be limited to education policy, but also involves economic development policy, urban development policy and most likely federal commerce policy.

- Given the federal role in “accrediting the accreditors,” encouraging regional and disciplinary accreditors to create and implement policies encouraging innovation, experimentation and entrepreneurship in developing new delivery systems, new modes of education and stronger relationships between outside constituencies and universities would be of substantial benefit. Accreditors play a critical role in quality assurance, but the impact unintentionally reinforces the status quo. Given the changes required of higher education to meet critical national need for STEM educated individuals, different approaches to accreditation that support experimentation are crucial.

No one is suggesting that accreditation should be eliminated or that it does not focus on quality. At the same time, it tends to be a conservative approach that reinforces the status quo definition of quality. Outcomes-based accreditation, rather than more input-based processes that are currently still the norm, can promote experimentation, innovation or entrepreneurial actions by universities and professions.

- Federal financial aid currently is focused on traditional degrees taken by full-time undergraduate students, yet all indications are that non-degree short courses, certificates, stacked credentials, and mixed traditional and apprenticeship programs offer great opportunity to expand the number and capacities of STEM-qualified students. Not reaching out and supporting students with great financial need (both traditional and older students) greatly reduces both the supply of STEM-qualified individuals and limits the abilities of the regions to expand STEM-based businesses. There should be much better alignment between the federal financial aid system and the rapidly changing environment in which we all are working.

According to news reports, this issue is under consideration by the Senate with regard to re-approval of the Higher Education Act, and it represents a critical opportunity for Congress to make clear its intentions with regard to the changing nature of academic programs that support STEM and other forms of education.

- Federal data-reporting requirements, especially through IPEDS, are woefully separated from the emerging realities of new forms of tertiary education. Because of how IPEDS is utilized within higher education, this is a major limitation that reduces experimentation and innovation. The focus of IPEDS simply no longer represents our reality in higher education and tends to lead both university leadership and various external policymakers to focus on very limited outcomes measures. Rethinking IPEDS and other federal data reporting systems to align them with the new approaches to education will be a clear signal to institutions of national priorities regarding implementation of new definitions of completion and performance.

- Currently, federal policy does little to encourage institutions to partner with external entities, and within the academy these partnerships often are derided as “corporatization of the university.” There is very little recognition within the academy or in federal policy that traditional organizational structures that supported the industrial economy are counterproductive in the post-industrial, technology-driven economy. Refocusing the missions of research universities to allow unique differentiation of the type of teaching, research and service they provide would be beneficial. Other countries with which we compete have already addressed this issue; for example, the development in the UK of “business facing universities.” The U.S. is very late to the table. Given the internal culture within much of higher education, policies that boost these external linkages can be of great benefit in encouraging institutional transitions to new models of education that promote quality within the highly technological, globally competitive world within which we now all operate.

In sum, it is time for Congress to consider Bayh-Dole 2.0. You can affect the competitiveness of our communities regardless of whether they are on the coasts or in the national heartland. Your actions today, in this and the next session of Congress, can mark the re-emergence of American competitiveness and drive the quality of life for future generations of Americans across the states.

Again, thank you for the opportunity to share with you what we are doing at Wichita State University, and I would be happy to respond to any questions.