

Learning, Research, and Collaboration in the Future.

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This White Paper introduces Iowa State University's symposium on "Learning, Research, and Collaboration in the Future." Its purpose is to be provocative, setting the stage for the university's ongoing conversation about planning for the university environments of the future, both physical and virtual. This White Paper is supported by a set of appendices which contains provocative questions for the three Working Groups that will be following up the conversations on Learning, Research, and Collaboration in the Future. We provide the reader with two perspectives for contemplating the future.

First, we begin with a simple thesis: information and communications technologies (ICT) are serving a singular role in transforming our practices in learning, research and collaboration. We describe examples of the leading edge of transformation in six areas that are critical to the learning, research, and collaboration environments on campus.

- Reshaping Scholarship, in General, and Research in Particular;
- Leveraging Mobility and the Distributed University;
- Enriching and Extending Learner Choices;
- Creating Flexible, Mixed-Use Facilities and New Breeds of Research Space;
- Concurrent, Reinforcing Developments: Globalization, Economic Development and Employability; and
- Public Research Universities as "*Great, Good Public Places*".

Second, we conclude with a discussion that links the "green shoots" of the leading edges of transformative change in learning, research, and collaboration with potential developments over the next 20 + years. This final section invites the reader to ponder and vision what learning, research, and collaboration experiences may look and feel like in the not-so-distant future, a future in which many elements cannot simply be extrapolated from past and present experiences.

Technology Transforms Learning, Research and Collaboration

Many factors have affected the continuing evolution of learning, research, and collaboration and the facilities that are designed to support them. However, we begin by focusing on the ongoing impact of information and communications technologies (ICT). Our broad focus embraces the full range of data, voice, and video communications made possible by ICT. The "C" feature of ICT deserves special attention. Changes in communications behavior, practices and culture have arguably been the most

transformative features of information and communication technologies. They have created new patterns and cadences in the lives of faculty, staff, students, administrators, and other stakeholders participating in the modern research university.

From the start, we should also acknowledge the ever-growing importance of information authentication and management in the new era. Also important: the capacity for data mining and leveraging of these repositories of authenticated resources. The vast and expanding troves of data, information, and analysis that are available ever more broadly have dramatically increased the need for information authentication and management tools, many of which need to be deployed automatically. Many of the traditional and future functions of land-grant Universities are depended on effectively understanding, deploying, and leveraging these tools of data authentication, management, and mining.

Technology has proven transformative through its singular capacity to enable us not just to do familiar things better or more efficiently, but to do familiar things differently, and new things that have never before been possible or even imagined. Information and communications technologies are the catalyst that is changing the behavior and culture of all enterprises in society, including institutions of higher education.

Transformation can be an overused term. Particular transformative practices that occur in one pocket of a university may not be deployed in the rest of the campus. In many institutions, traditional practices continue substantially unchanged, with merely a technology and process veneer placed on top. Still, examples of transformative change are available for examination. As William Gibson wrote in The Neuromancer, "The future is already here, it just isn't distributed very well." (1) However, there are many competing futures to consider, and through our judgments we can influence which future wins out. Different evolutionary paths are available to universities considering their futures.

Information and communications technologies have been a major catalyst in enabling change in learning, research, and collaborative practices. They will continue to do so in the future, perhaps with accelerating impact. ICT has fostered changes in practices and behaviors of faculty and learners, stimulated fresh combinations of learning and scholarly activities, and enabled new variations of physical facilities. ICT has extended the outreach of the university, making the campus accessible to global populations, and vice versa. ICT has allowed learners to choose from and exercise multiple options, both within the university campus and beyond. In a very real sense ICT has accelerated the very positive shift from teacher "centric" models to learner "centric" models, especially for post secondary education.

Information and communications technologies have impacted land-grant Universities and outreach activities in substantial and particular ways. ICT has enabled many more players to enter the outreach arena (non-land-grant universities, for-profit institutions, and other information-providing organizations). The more established outreach-oriented universities (land-grants) have employed information and communication technologies to reach new, broader audiences as well as more efficiently connect with established audiences. Outreach has grown from scarcity to abundance, with more options than ever before. In this environment, it is important for all sectors providing outreach to identify the activities and audiences for which they can provide the most cost-effective, value-added services. In this way intelligent choices can be made between competing options by both learners and providers.

Examining Six Elements Shaping Emerging Environments and Practices. So we begin these conversations with the notion that information and communications technologies have been reshaping many of the factors of change that have affected colleges and universities. We shall focus on six elements that are combining to shape the emerging environments and practices for learning, research and collaboration in the future:

- Reshaping Scholarship, in General, and Research in Particular;
- Leveraging Mobility and the Distributed University;
- Enriching and Extending Learner Choices;
- Creating Flexible, Mixed-Use Facilities and New Breeds of Research Space;
- Concurrent, Reinforcing Developments: Globalization, Economic Development and Employability; and
- Public Research Universities as “*Great, Good Public Places*”.

Our intent is to explore these six factors, focusing on their particular impacts on research, learning, and collaboration.

Reshaping Scholarship, In General, and Research in Particular

Over time, information and communications technologies (ICT) have reshaped the patterns, cadences, and practices of scholarship. This has affected virtually all scholars, individually. It has also impacted individual scholars as members of working groups, teams, departments, and disciplines. Moreover, the evolving patterns of Knowledge Age scholarship are not following a single path. Substantial variations exist by discipline. Alternative paths to the future are available and may be chosen by particular disciplines, sub-disciplines, or emerging multi- or trans-disciplinary congregations of knowledge practitioners.

Reshaping Scholarship, Profoundly. Ernest Boyer (2) characterized scholarship as consisting of a continuum including discovery, application, integration and teaching. In his article “Scholars, Scholarship, and the Scholarly Enterprise in the Digital Age,” Richard N. Katz asserts that ICT has been empowering, enriching, and enlarging scholarship and raising its impact by:

- rapid and low-cost connection with others;
- tools that promote our capacity, individually and in *ad hoc* work groups, for multi-tasking, multi-processing, and otherwise dividing our attention;
- the interconnected and accessible complex of digital instruments and visualization techniques that make it possible for us to work at nano- or cosmic scale; and
- access to an abundance of easily discovered, recorded knowledge.

Katz goes on to point out that

“These very new capabilities are destroying distance and demolishing barriers of all sorts. They are liberating scholars from many traditional bounds of culture, community, and practice. They are redefining or even eliminating the rationing of academic tools and resources (e.g., space telescopes, particle colliders). They are predisposing scholars to a scholarship of open content, knowledge, and learning. And they are liberating us all from the ‘busy-ness’ of knowledge work.(3)”

By “busy-ness”, Katz means the slow, pre-Internet and pre-mobile technology processes of data collection, validation, and analysis, all of which have been accelerated and reshaped by ICT-enabled tools, practices, and networks.

The reshaping of scholarship, enabled by technology, comes with some cautionary notes. As pointed out by Katz, networked connectivity enables individual learners and problem solvers not associated with the university to find non-traditional routes to insight. Such knowledge used to be available only through faculty and researchers on campus. This can mean a loss of prestige and income to universities.

However, it could also support the emergence of new generations of knowledge management and validation tools and practices. Or even a renaissance in “amateur” research, exploration, and commercialization, distributed across the globe.

The growth of grass-roots research, innovation and entrepreneurship could be a boon to land-grant universities. Much so-called amateur knowledge needs to be vetted and quality assured, and the rapidly growing body of knowledge begs to be mined for new and germane developments and meta-analyzed for emerging patterns. These acts of discernment could be an important contribution of land-grant universities to what our nation’s leaders hope will be a renaissance of innovation-driven growth and development

Moreover, the accelerating pace of new knowledge creation is straining the capacity of scholars to keep up. This will only get worse as new knowledge hubs spring up across the global economy and higher education space, adding new scholars and innovators and their contributions to the body of knowledge. Burgeoning numbers of practicing scholars and active researchers may support the deployment of new generations of research support tools, repositories, and services.

In spite of these cautionary notes, the technology-driven reshaping of scholarship will continue to be a highly positive force, on balance. It will enable profoundly networked individual faculty and teams to increase their connections with peers and sources of fresh knowledge, and to raise their attractiveness to funders.

Transforming Research in Particular. While information and communications technologies have reshaped *all* aspects of scholarship, the land-grant universities are particularly interested in their impacts on discovery and applied research and related commercialization activities. Leadership is also keenly interested in the impact on the facilities in which all of these are conducted. To understand the future developments in research also requires insights on the societal and funding priorities and other driving forces that are reshaping the practice of research.

The most profound impact of ICT in research has been to support and facilitate the increasing multi-disciplinary, team-based approach to basic research and research-supported problem solving. The demand for multi-disciplinary approaches is on the ascendancy for several reasons.

- First, the truly interesting new areas for research inquiry typically occur at the boundaries and intersections of existing disciplines and at the junctions between existing disciplines and new fields of inquiry; to access those areas of promise requires an inter-disciplinary perspective;
- Second, the problems that are typically addressed by the applied research of the professional and helping disciplines involve a combination of political, economic, social, and cultural factors and are by their very definition complex and multi-disciplinary; practical problem solving requires both pragmatism and multi-disciplinarity;
- Third, as the lion’s share of the fresh resources available to education and research universities flow to the STEM-centric disciplines (science, technology, engineering and mathematics), shrewd practitioners in the other disciplines realize that they must find ways to participate in multi-disciplinary, team-based research endeavors if they are preserve a viable place for their disciplines in the 21st century university. In the long-term, serious research efforts to address energy, transportation, water, health, and sustainability challenges must be framed to engage practitioners from many disciplines, trained to participate in multi-disciplinary teams that address real-world problems. This will also require practitioners in all disciplines to be “STEM-literate” at some level.

These issues are especially important to land-grant universities such as Iowa State University, because the research, complex problem solving, and social engagement agendas of these institutions are likely to become even more important to their viability in the coming future. Attracting increasing levels of outside support for research (from both government and industry) will be even more essential in the coming decades.

Forecast of the Future Impact of Technology-Based Innovations in Key Areas. The future directions in university-based research will depend strongly on public policy imperatives established by the federal government and translated into research support. It will also depend on corporate support for emerging technologies and innovations having commercial potential. The TechCast Project at George Washington University (4) provides an expert opinion-driven observatory on future technology and research-driven developments. It spans a wide range of scientific fields: energy and the environment, information technology, e-commerce, manufacturing and robotics, medicine and biogenetics, transportation and space.

This forecast projects that the currently accelerating advances in information technologies are making the world smarter, faster, and fully connected, and will set the stage for even greater breakthroughs to come. By 2020 significant breakthroughs in green business, alternative energy, and other ecological practices will improve sustainability; artificial intelligence and the next generation of quantum, optical and biological computing will permit great leaps in telemedicine, e-government, and virtual learning and competence building; biotech should provide personalized medicine, genetic cures and other healthcare advances. Even more substantial advances are possible by 2030. However, the forecast suggests that taking advantage of many of these technology breakthroughs will require a “New Maturity” in decision making, problem solving, and solution deployment.

Of course, it is difficult to hang one’s hat on any particular forecasts of the future of technology breakthroughs and innovations. Moreover, projections of federal and corporate funding are even more imprecise. Further, projections of future outcomes from technology breakthroughs are inexact, as well. Just this week, Tyler Cowan’s new book *The Great Stagnation*, builds on earlier work contending that over the past fifteen years, technological breakthroughs have failed to drive commercialization, resulting productivity gains, and economic well-being in the manner that characterized much of the post WWII era (5). So the debate continues. One thing is clear, however. Externally-funded research, driven by societal and commercial needs, will be an increasingly critical element of the public research university in the future.

Leveraging Mobility and the Distributed University

University campuses progressively have become technology-rich environments. Learners, faculty and researchers access ambient technologies that are embedded in facilities (e.g., classroom technology, research lab technology, collaborative space-sited projection screens, data visualization and artificial/augmented reality facilities, embedded sensors and intelligence). Through mobile technologies, individuals can connect and collaborate anywhere on campus. Taken together, these capabilities have the effect of fusing physical and virtual spaces

Transforming e-Knowledge: A Revolution in Knowledge Sharing (6) describes the ways in which peers, professional colleagues, and others can use ambient technology environments to collaborate more easily and extensively. These environments can also fundamentally change the way that learners, faculty, researchers, and practitioners share and experience knowledge. These same capabilities are changing the venues and practices for community problem solving, extension activities, and public service. Most faculty on most universities campuses have become part of a distributed ecology of regional, national and global collaboration. Networked collaborations have blurred or even erased the boundaries of campus.

A new term, *M-learning* (7) encompasses learning with portable technologies including but not limited to handheld computers, MP3 players, notebooks and mobile phones. M-learning focuses on the mobility of the learner, interacting with portable technologies, and learning that supports the needs of an increasingly mobile population. M-learning is moving beyond laptop devices to smart phones, iPads, and new concept devices made possible by technology convergence. Habituated smart phone users have moved well beyond telephony, using their phones as cameras, GPS devices, personal organizers, Web searchers, and text messagers. As next-generation devices become more powerful and amenable, and emerge in sanctioned university usage, they will change the way learners and faculty engage and experience knowledge.

An emerging body of knowledge from research and observed practice asserts that new, convergent technologies are serving to augment, complement, and extend existing capabilities. The new combinations of practice supported by these devices enable new and more effective approaches to learning, discovery, innovation, and collaboration. The challenge is to create, nurture, and leverage these convergent technology-enabled environments.

Research conducted by faculty and students also benefits from mobile devices. Field research teams use smart phones and similar devices to collect data and record phenomena. Many bench scientists in corporate research labs and some academic settings use electronic laboratory notebooks as part of an ambient environment for data capture, management, and manipulation. One variation of these products (8) automatically captures laboratory results and provides data tracking and capacity to record and replicate results, all of which improves workflow and quality of research processes and data management.

The future campus technology environment will likely include new embedded and mobile tools. As Mark Weiser observed, "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" (9).

Enriching and Extending Learner Choices

For the first time ever, institutions are serving four distinct generations of students: Millennial learners, Gen X, Boomers, and some remaining traditionalists. These learners have distinctive preferences in styles of learning, communication, problem solving, decision making, leadership, feedback, and use of technology (10). Collectively, these groups demand a wider spectrum of options than institutions have ever experienced. Millennial learners' preference, particularly, are pushing many faculty and institutional support systems beyond their comfort zones.

Focusing on Effectiveness and Optimizing Learner Success. To meet these varying needs and preferences, educators at leading public universities like the University of Central Florida (11, 12) have established Centers for Effective Teaching that assess the learning needs of different groups and address them through a selection of online, blended and e-learning options. They have also address the collaborative needs of different learner groups and the ways that these needs require different kinds of learning spaces. Many institutions have evolved their institutional research operations into institutional effectiveness enterprises, focusing on learner outcomes and success in their particular environment.

In these changing times, universities are rediscovering the need for effectiveness research that focuses on the needs and characteristics of their particular learners. Local context may take on increasing importance, particularly if those local contexts diverge from national/global trends and as diversification (increasing specificity) of missions occurs in response to balancing scope and resources. A number of land-grant universities are well known for their efforts in these areas. John Campbell and Kimberly Arnold from Purdue University have written about their utilization of embedded, predictive analytics (13, 14) in recruitment, retention, and student success programs. In particular, Purdue's Signals program has been

written about in professional publications, showcased on national nightly news, and commercialized and made available to other universities. Signals uses predictive analytics and intrusive advising to offer freshmen in gateway courses a daily scorecard on how their academic progress and behaviors compare with those of past students who have been successful in these courses. More advanced success-improvement practices are in the works, based on predictive analytics embedded in academic and support processes.

For over a decade, groups like the EDUCAUSE Learning Initiative (ELI) and the Society for College and University Planning (SCUP) have been exploring new kinds of learning spaces and learner-centered environments, tailored to the needs of today's learners. Diana Oblinger's 2006 book, Learning Spaces, contains dozens of useful examples (15) from institutions creating new learning space solutions, one new building at a time. These features have since been being incorporated into new buildings and added to older buildings through retrofitting. As a result, proven formulas about the optimal mix of classrooms, lecture halls, labs, and other traditional facilities are changing. Mark Valenti's perspectives on the physical embedding of convergent technologies into the new generation of learning spaces (16, 17) have charted the course for flexible, collaboration-rich spaces that have the flexibility to continue to evolve with new technology refreshments every few years.

Alternatives to the Campus-Based Experience. Yet another perspective on the learning needs and preferences of Millennial students was showcased in Anya Kamenetz's recent provocative book, DIY U: Edupunks, Edupreneurs, and the Coming Transformation of Higher Education (18, 19). Kamenetz has written about the financial challenges faced by Millennial learners in affording traditional higher education and getting started in their careers. Her book profiles the wide range of open and free-range learning options available to Millennial learners, providing alternatives or complements to traditional learning. In many parts of the United States and internationally, these options are gaining in popularity. Kamenetz suggests that unless traditional institutions respond to both the nature and affordability of learning, Millennial learners will choose the options enumerated in her book – in droves.

The reality is that there are already substantial numbers of alternative approaches to traditional higher education that are operating, being tested in the marketplace of ideas, and seeking acceptance by learners – and by employers (20). For example, transformed learning models like Western Governor's University are offering a bachelor's degree in accelerated time frame, well received by employers, and priced at \$15,000 for many accelerated learners. LearningCounts is an on-line, national utility for certifying credit for prior learning that is offered by the Council for Adult and Experiential Learning (CAEL) and is being recognized by a growing list of institutions. Moreover, virtual high schools across the country are reaching not just home schoolers, but smart and bored young people who were failing in the traditional high school experience, then reengaged by engaging, challenging virtual learning. By 2020 even students choosing traditional universities will have experience with alternative approaches and will expect to have attractive choices tailored to their learning preferences..

Creating Flexible, Mixed-Used Facilities and New Breeds of Research Space

In his visionary book, City of Bits: Space, Place, and the Infobahn, William Mitchell (21) described the impact of the Internet and pervasive connectivity on the design of facilities. In the past, academic buildings were edifices to single or closely related functions – libraries, classroom and office buildings for particular disciplines, administrative buildings, student unions and the like. Mitchell points out that technology-rich facilities provide physical and programmatic flexibility enabling people to move effortlessly from function to function, fusing these activities seamlessly. Mitchell predicted the emergence of new generations of mixed-used facilities. Examples in higher education were described in Space: The Final Frontier (22), including:

- Reinvented computing and learning resource centers (libraries) such as the Learning Commons at the University of Calgary, Learning Resource Center at Thames Valley University, and Computing Commons at Arizona State University;
- Multi-academic-use facilities aiming to fuse and change teaching, learning, and research, such as the Media Union at the University of Michigan; and the Integrated Technology Learning Lab and ATLAS (Alliance for Technology, Learning and Society) Center at the University of Colorado at Boulder; and
- The George W. Johnson University Center at George Mason University, a combination of reinvented student union, library, academic and collaboration center that resembles “an academic mall;” and the Price Center at the University of California San Diego which is a classroom/lecture hall by day and a commercial theater in the evening with fast food, small retail shops and the campus bookstore thrown in for good measure.

This new breed of space has been further endowed with increasing degrees of flexibility in technology support, furniture, and even physical configuration. Many new buildings are seen as “expeditionary,” that is, their configuration is progressively being changed to address evolving needs and preferences. At the same time, campuses are placing greater emphasis on retrofit, infill, and ways of enhancing or reclaiming existing facilities rather than building anew.

Creating New Breeds of Research Space. On many campuses, faculty, researchers, staff, and architects have also collaborated to fashion new forms of discovery spaces, laboratories, and collaboration spaces. The new breed of research space pays close attention to flexibility, multi-disciplinarity, adequate support services, and changes in the way scientists conduct their business today, and in the future.

The emerging design principles of research laboratories are discussed in several related portions of the Whole Building Design Guide (23). developed by the National Institute of Building Sciences. They assert that the new model of laboratory design, responsive to present practices and capable of accommodating future demands, is being driven by several key needs:

- to create “social buildings that foster interaction and team-based research;
- to achieve an appropriate balance between “open” and “closed” labs;
- for flexibility to accommodate change;
- to design for technology to provide access to electronic communications systems throughout the building, having immense implications on lab design; and
- for environmental sustainability.

The need for “social buildings” emphasizes the importance of collaboration spaces that include meeting places such as break rooms, meeting rooms, atrium spaces, cafeteria and café spaces and even stairwells. In today’s research facilities, every square foot of space is potentially collaboration space. Team-based labs are also an epicenter of collaboration which can be encouraged by the use of flexible systems and casework that enable altering space to meet changing needs of the research team. Other mechanisms include designing offices as places where people can work in teams, providing ample white board space and projection screen space in team working areas, and using interior glazing so people can see one another.

While flexibility is valued, it can be expensive. Institutions need to carefully integrate and optimize, not maximize, the use of flexible elements, creating combinations of:

- flexible engineering systems,

- shrewd use of equipment zones,
- using generic lab design where possible,
- mobile casework,
- using the full volume of the lab space,
- overhead service carriers, and
- careful balancing of dry lab/wet lab needs.

Researchers have changed their patterns of research work over the past decades and we expect those changes to continue apace or even accelerate. Robert McGhee of the Howard Hughes Medical Institute observes, "Twenty years ago, people spent 75 percent of their time at the bench and 25 percent at the desk; today that ratio is almost reversed. The increasing role of computational science in research suggests that capacity to support computing devices must be pervasive and that the desk and bench configuration should be able to accommodate both wet and dry activities.... the traditional four foot desk/eight foot bench is a problem." (24) Future changes are likely to include increased capacity to merge virtual and physical laboratory work.

Some of the best examples of flexible, multi-disciplinary laboratories are corporate laboratories such as the EPIC facilities in Verona, Wisconsin, and the Cargill Research labs in suburban Minneapolis. These facilities are highly multi-disciplinary, planning for the continual evolution of fresh, multi-disciplinary lines of inquiry. Commercially-driven laboratories in fields like pharmaceuticals are continually re-evaluating their lines of inquiry and abandoning endeavors that have lost their promise. In these settings, researchers often are required to reinvent their areas of interest more aggressively than in typical academic settings and the laboratory spaces need to be capable of responding to such changes. To reinforce this point, in the Whole Building Design Guide Daniel Watch and Deepa Tolat observe the "Many private research companies make physical changes to an average of 25% of their labs each year. Most academic institutions annual change the layout of 5 to 10% of their labs. (25)

The Janelia Farm Research Campus of the Howard Hughes Medical Institute in Ashburn, Virginia, is another example of flexible, open, multi-disciplinary space. The Janelia Farms labs are characterized by a larger amount of shared support space, increasingly sophisticated support services, and greater flexibility for retrofit. Mobile equipment and bench configurations at Janelia Farms also provide access to integrated food service and collaborative space. These examples provide interesting models for the future of space design (24) that sustain the principles summarized in the Whole Building Design Guide.

Several of the newer academic facilities on the Iowa State University campus (Hach Hall, the Biorenewables Research Laboratory, Hoover Hall, and the Gerdin Business Building) exhibit some of the multi-disciplinarity, use of collaborative space, and flexibility that characterize these models. Indeed, the Biorenewables Building was recently recognized in College Planning & Management for winning LEED Gold Certification and for promoting interdisciplinary, systems-level research and collaboration (26). The BRL is "the first phase of a new biorenewables complex that is designed to showcase the State's and ISU's commitment to the development and research of biorenewable resources, support interdisciplinary research and teaching, promote the campus biorenewables education and outreach activities, and serve as a model for sustainability (26)."

Changes in the Ecology of Research Activities. The multi-disciplinarity and team-focus of modern research are not the only factors requiring flexibility. Individual research programs are also changing in both size and the nature of activities. Most faculty researchers go through a predictable cycle in the size and activities of their labs, starting out with just a few students and employees, growing to many, and then shrinking as their grants drop, they move to administration, or they get ready for retirement. This can create enormous problems in space management and in sub-optimized or even wasted space; moving a once grant-intensive faculty researcher to a smaller lab is both difficult and disruptive.

Perhaps this means universities should consider a greater shift to strategic, team-based research priorities that are less tied to single individuals. The increasing use of remote and distributed laboratory and computational facilities and researchers could facilitate this move. This could involve universities seeking greater similarity to non-university research organizations, while still maintaining an environment that also fosters single investigator-based research when appropriate. These are all issues for universities to consider as they approach the future of their research enterprise.

Concurrent, Reinforcing Developments: Globalization, Economic Development, and Employability

Other powerful forces are contributing to the transformation of learning, research and collaboration in universities of today – and tomorrow. These present distinctive opportunities for land-grant universities.

The Emergence of Global Research Universities. Concurrent with the development of the distributed, open university, globalization has emerged as a fundamental driving force for society, the economy, and universities. The globalization of the economy has established a new gold standard for the education of graduates, increasing the demand not just for study abroad, but for development of skills and perspectives for the global marketplace. Across the globe, both developed and developing nations have been following the example of the American research university. Over the past twenty years, other nations have dramatically boosted their investment in universities. They are placing greater emphasis on research and knowledge-based economic development. These activities are creating new opportunities for collaboration (and competition) and promise to shift the balance of prestige in university rankings.

For American research universities, globalization-based developments present both opportunities and challenges. In *The Great Brain Race: How Global Universities Are Reshaping the World*, Ben Wildavsky (27) describes the unprecedented international mobility of students, the rapid spread of branch campuses of American “transnational” universities, the growth of for-profit universities, the development of research centers of excellence in Eastern China and elsewhere, and the remarkable expansion and morphing of international league tables. Paul Lefrere offers the European perspective on how the globally competitive future may develop (28) – they foresee several scenarios for change, all involving dramatic changes in the relative balance of prestige in international academia. Understanding this context is important for Iowa State University as it plans for its future learning, research, and collaborative relationships.

Economic Development and Employability Take Center Stage. The open, distributed research university is also impacted by several other contextual factors facing public universities: the need to stimulate economic development and improve employability. In lifting out of the Great Recession, states are expecting their public universities to redouble their efforts to be engines of economic development. The public is pressing universities to be more accountable, improve their performance and pay greater heed to preparing their graduates for employability – to live a good life and make a good living. These expectations play to the traditional strengths of the land-grant university.

These are also global concerns. Virtually every economy across the globe is experiencing some variation on a common and interconnected set of themes:

- high unemployment and underemployment, post-recession, especially among the young;
- pervasive talent gaps, where employers cannot find the people they need in sufficient numbers for high-competence jobs;
- mismatches between what college graduates have learned and what employers need, and
- economies that are not producing enough new jobs to employ increasing pools of college graduates (29).

These themes are playing a major role in the current unrest that has spread from Tunisia to Egypt and across the Middle East. But these are also bubbling issues in China, the United Kingdom, most of the European Union, and the United States (30). Employability will be at the center of the education agenda, globally.

The Evolving Role of the Land-Grant University. Public research and land-grant universities will likely play a major role creating a secure economic and employability future. The potential future roles of the land-grant university are addressed in a compelling manner by Lou Anna Kimsey Simon, President of Michigan State University. In her White Paper Embracing the World Grant Ideal: Affirming the Morrill Act for a Twenty-first-century Global Society, (31, 32) Dr. Simon contends that land grant universities should naturally extend their traditional roles by participating in “*engaged scholarship*” that serves as an engine of prosperity for the common global good, creating circumstances in which ordinary individuals can achieve their extraordinary potential. She contends:

“ At its core, the World Grant ideal is not about dominance or status. It is about comprehensiveness, caliber, impact and the value of inclusiveness, connectivity, and quality. It is about helping people and communities – local, national, and global – to realize their dreams and make their dreams better.”

If Dr. Simon’s vision is true, then globally engaged learning, research, and collaboration are an attractive imperative for the land grant university of the future.

Public Research Universities as Great, Good Public Places

Peter Drucker famously made the comment that “the modern university is a relic that will disappear in a few decades” (33). His prediction was based on extrapolating the digitization, dispersion, and democratization of knowledge that would provide other, less-expensive, “good enough” alternatives to traditional, classroom-based learning. In the wake of the Great Recession, other pundits have opined that higher education may be a “bubble” like real estate or newspaper publishing (34), waiting to burst. A weak economic recovery and parlous state finances does not breed confidence.

In reality, the modern land-grant university is positioned to thrive in the global brain race of the 21st century. The public, distributed research university we have described is empowered to engage learners, researchers, community problem solvers, and citizens throughout the state, the nation, and globally. This does not mean that some parts of the university may not need reinvention. In order to capitalize on its opportunities, public research universities will likely need to reimagine and reinvent substantial elements of their learning, research, and collaboration systems and processes.

The land-grant university of the future will need to be an even more profoundly networked and virtual enterprise. In addition to virtual engagement, however, the land-grant universities campus will continue to be viewed as a “great, good public place” that will increasingly attract people to campus and physical “satellite” locations for a wide variety of activities. Research, economic development and employability have long been its strong suits. The challenges and opportunities facing the university is how to leverage both its physical and virtual resources, assets and experiences in fulfillment of its mission of service.

For some time, observers of online enterprises have realized that virtual activities are optimized when they are combined with face-to-face interaction at real, physical places. Online learning enterprises like Capella University and the University of Maryland University College have always found the need for satellite learning facilities or periodic convenings rather than relying totally on online interactions and engagement. Vibrant virtual collaborations and research ventures benefit from face-to-face interaction and serendipitous ideas flowing from time spent together, physically. This phenomenon is euphemistically

called “bricks and clicks” or “clicks and mortar,” While the rumors of the demise of great universities were premature, the exact look and feel of tomorrow’s “augmented reality” universities is still evolving.

Conclusion: Learning, Research, and Collaboration in the Future

To rephrase William Gibson’s observation: we can observe the leading edge of the future all around us. We have already described the “green shoots” of changing practices in learning, research, and collaboration. The temptation is to extrapolate these developments incrementally into the future, understanding full well the slow pace of substantial change in universities. After all, our experience tells us, universities are complex organizations that have extensive physical facilities and research infrastructures already in place – or already under planning/construction or conceived and waiting in the funding queue.

However, there are forces at play that may cause acceleration in the pace of change – reductions in the patterns of public funding, changing societal demand, concern that increasingly costly higher education may be the next bubble to burst, and the increasing focus on employability. Crises have ways of focusing the attention – after all else fails. They also empower new competitors to take the aggressive actions that existing, complex enterprises cannot, fully engaged as they are in delivering products and services under the existing paradigm.

We have explored how information and communications technologies are enabling genuine transformations in our perspectives and practices. Several questions emerge:

- Will the transformative potential of ICT be even greater in the future?
- Is the virtual university, laid atop and interacting with the physical university, the reality space where more substantial changes can occur in learning, research and collaboration?
- Will they enable new kinds and levels of engagement that we can barely imagine, today?
- Will the demands to improve employability require more effective feedback loops with industry and the economy than exist today?
- Will new, nimble competitors grow to capitalize on the opportunities, outpacing slower moving universities, and in the process push universities to accept new practices?

The future will answer these questions itself, over time. But we can use foresight to discuss alternatives and scenarios under which we must position the University to be successful. For today, we conclude by offering the following brief snapshots. They suggest of how our current experiences with the leading edge of the future will collide with the forces for substantial change over the next few decades.

Learning. Today, Iowa State University (and other institutions, as well) are grappling with the fresh learning preferences of mobile millennial learners (in addition to serving several generations of more traditional learners). These learners are functioning in today’s evolving campus learningspaces, both physical and virtual.

The next generations of learners will be even more digitally native than today’s Millennials and even more demanding. In the future, the physical and virtual university will become even more profoundly intertwined. This will enable learners at all stages of their careers to fuse learning, extra-curricular and co-curricular development, employment preparation and experiences, immersive problem-solving, community engagement, and other activities connected with the global research university and with society at large and the world of work. The university will engage learners earlier in their careers (in K-12) and continue longer (life-long relationships), but in more substantial ways. The learning experiences of individuals at all levels will be increasingly immersive, team-based, and connected with problem solving and application. Physical learningspaces will evolve through redesign and retrofit, using progressive

generations of refreshed technologies to engage the denizens of the virtual, boundary-less university in new ways. Mobile learners, armed with new generations of devices that may as well be physically embedded (and may actually be embedded, over time), will turn every space into a space for learning, research, collaboration – or whatever.

Not all universities will respond equally to these developments and the opportunities associated with them. Especially in the areas of preparing for employability and providing student success-making services, more nimble enterprises will compete with the university to frame and serve learner needs and aspirations. Universities will need to participate with a more diverse constellation of new enterprises in the future work and learning space.

Research. Today Iowa State University continues to experience evolution in research practices and new laboratory facilities that reflect the trends toward multi-disciplinary, team-based discovery; greater openness and flexible, and collaboration-friendly facilities, and greater participation in research by undergraduates. Individual scholarship is being reshaped by the use of information and communication technologies in virtually all disciplines, in distinctive ways.

In the future, discovery research, application and commercialization will become even more important to the relevance, societal contribution, and financial sustainability of Iowa State University. It is likely to constitute an increasingly large proportion of campus activity and resources, and generate commensurately more revenue. Participation in research, community problem-solving activities, and immersive, team-based collaborations will become increasingly important for students at all levels and faculty in all disciplines. The disciplinary fabric and structure may change dramatically to accommodate the challenges facing the research university in the next decades.

The future reality shall include:

- Development of new research facilities (many funded privately) both those in the current planning queue and others driven by societal/private demand,
- Retrofit of existing facilities to new perspectives, practices, and opportunities;
- Pervasive engagement in virtual research using virtual equipment and devices located in other locations around the world ,
- Reimagining academic disciplines, the relationships among them, and the patterns of participation in team-based research and complex problem solving.

The interaction of these factors will reshape institutional priorities for investing in programs, facilities and people.

Virtual research and collaboration will enable practitioners to overcome limitations of existing physical space. Remotely shared equipment, widely distributed research teams, and using e-tools to bring quality assurance to research practices will be common practice. Virtual scholarship tools and the use of artificial intelligence (AI) agents will revolutionize not just individual scholarship, but the replication of findings and commercialization.

For the United States to succeed in the 21st Century, the nation will need to invest in education and research, infrastructure development, and research-initiated innovation. To compete effectively for federal and corporate research and commercialization funding, Iowa State University will need to offer a research environment and an ecology of discovery research and problem solving that is seen as highly effective and flexible in addressing the challenges of the day – and the future.

Collaboration. Today, the patterns and cadences of collaboration at Iowa State University have been changing to reflect national and international trends. The role of technology-enabled collaboration is reshaping the roles and experience of students, faculty, researchers, staff, and other participants in the modern, distributed research university.

In the future the new generation of amenable tools of collaboration will facilitate previously impractical interaction among students, faculty, staff, researchers, and other members of the Iowa State University community. These tools will also facilitate collaboration with a constellation of external organizations and individuals: drawn from all over the world. The TechCast Project (4) predicts that by 2014 it should be possible for most people around the world to interact via intelligent PCs, the Internet, TV, smart phones, and globally media – and be translated automatically and instantaneously. In addition, more user-friendly user interfaces will remove current boundaries to participants who are less-than-savvy about digital navigation. In such an ecology of collaboration, students, faculty, researchers and staff at global universities could engage in remarkable experiences, together, while being located almost anywhere.

Moreover, projections suggest that by 2020 we will have deployed a generation of far more sophisticated IT networks, a second generation of more powerful computers, smart robots that think and talk, and other AI-based tools that will automate many aspects of routine knowledge work. The impact of this new ecology of collaboration and problem solving will profoundly affect the experiences of everyone affiliated with universities. It will also affect the world of work, civic engagement, citizenship and societal problem solving for which we prepare – and continuously refresh - university graduates. These new environments will create

In his book, [The Singularity Is Near](#), Ray Kurzweil (35) described the world of powerful artificial intelligence that will likely exist after 2020. His description of the cyborg-like possibilities of fused human/machine intelligence leaves most people outside academe skeptical and nervous. However, the sorts of technology-based innovations and working environments projected as possible by the TechCast project by 2020-2030 could fundamentally alter the roles of senior researchers, graduate students and undergraduates in scientific research and in meta-analysis using research findings. As we are discussing scientific and knowledge-based collaboration in the future, we need to expand our thinking to consider what the world of research, discovery, application, and innovation will look like in 2020 - 2030 and beyond.

So we are left with the question: What will the experiences of learning, research, and collaboration – and all variations of the thing we call scholarship – look and feel like in that unseen future that lies beyond the curvature of the earth from our vantage point? How can we position Iowa State University for success in whichever of those future permutations come to pass? And how can we position the University to be highly successful in competing for the financial and human resources necessary to fulfill its mission of service to the State of Iowa, the nation, and the global community in which we all function.

In the words of Jonathon Swift: “Vision is the art of seeing things invisible.” It is time to envision the possible, invisible futures for Iowa State University.

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