Global Sustainability Solutions Services

The Net Positive Valuation of Information and Communication Technology in Online Education

A comprehensive report prepared April 2015

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1. Overview

Online education has been evolving in the American undergraduate education system over the last two or three decades, and the use of information and communication technology (ICT) for this purpose has exploded since the 1990s.

The concept of net positive has emerged as a new way of doing, measuring and reporting business that recognizes the importance of putting sustainability at the core of business strategy. To be “net positive” simply means to put more back into society and the environment (called handprint) than to take out of it (called footprint). This report focuses on a preliminary case study of the net positive impact of ICT in the online education market, utilizing the current ASU Online education program for undergraduate degrees as the case study.

The primary research method used was a set of structured interviews of experts with knowledge of the education market, online education, ASU, ASU Online and the use of ICT platforms in each. High-level models of key stakeholders and variables were developed. They were then populated with results from the interviews, related research findings reported in the literature and with secondary data already collected for the ASU Online and sustainability case. The unit of analysis used is the delivery and completion of undergraduate degrees.

A holistic value proposition table is presented for the relevant stakeholders based on the structured interviews. In addition, the net positive impact implications of stated goals for the delivery of undergraduate degrees at ASU by 2030 are explored. A key finding is that up to 75% of all undergraduate courses may be delivered in an online format and that all courses will be delivered on the same ICT platform by 2030. The overall impact of an increased use of ICT will be a drastic reduction in the campus infrastructure required to deliver a target number of degrees relative to any current or past undergraduate education models. Finally, a “snapshot” model of the current situation is presented. The model posits carbon savings of 28.3 t CO_2e and socio-economic benefits of $545,000. Key variables included in the net positive impact model for ASU Online are:

(1) Elimination of student commuting for online students as compared to immersive degree students (also referred to as campus-based, face-to-face (f2f) or brick and mortar students);

(2) Reduction of the annual energy footprint for online students as compared to immersive students in terms the construction and use of campus facilities;

(3) Increased ICT use for complete online delivery of a degree;

(4) Enablement of graduation (via online access) from an outstanding undergraduate degree program for students with significant credits already earned toward a degree;

(5) Enhancement of average lifetime earnings for students enabled to complete a degree (as reported in the literature);

(6) Avoidance of social costs for individuals enabled to complete an undergraduate degree (as reported in the literature).

2. Literature Review

As a way to prepare for conducting the net positive valuation of ICT in online education, a literature review of published studies in areas that are relevant to a net positive assessment of online education was conducted. The purpose of the literature review was to examine where research is being done in the areas of online education, the role of ICT in online education and their respective impacts on society. As net positive is a relatively new concept, it proved difficult to find any studies that explicitly studied online education from this point of view, so our search terms were focused on various aspects of online education that create value or impacts to society. Our search terms included terms such as: value of online education; diversity and online education; how to value online education; net positives of online education; evaluating online education; valuing social benefits; valuing environmental benefits; role of technology in online education; social return of online education; carbon offset of information technology; environmental impact of information technology; collective social value of online education.

Search results were filtered and the articles most closely related to the purpose of the analysis were selected to create a final collection of over seventy studies and books. Three major categories of academic research that were the most prevalent in examination of value and impacts of online education emerged: broad overviews of online education and its prevalence in society (20 articles), drivers of the quality of online education (23 articles), and the environmental impacts of information technology systems (11 articles). A fourth category of literature (6 articles) was identified that focuses on the social and economic value of education. The remaining literature (13 articles) was categorized as miscellaneous because the articles were unique, relevant and did not fit into the other literature categories. This group of literature included articles about organizational strategies for sustainability and articles about environmental and technology valuation.

Information gathered from the literature search is used throughout the report. This summary of the literature review is concluded with a brief history of ICT in undergraduate education in the USA. This view has been put in a decade-by-decade format for ease of presentation and understanding of major shifts. Obviously, the transition periods overlap and blur because of the rapidly changing pace of change in ICT and its implementation in the university setting. Since the turn of this century, the pace of change has created a major disruption in the delivery of undergraduate degrees. A brief history of ICT Impact on undergraduate education in the USA follows:

1950s – Mostly accounting, financial and records use of computers for undergraduate students. Environmental impact: Minimal.

1960s – Class scheduling by computers, computer modeling and programming by students, computer assisted instruction methods introduced. Environmental impact: Substantial increase in power and paper usage.

1970s – Availability of computers to all students through use of dumb terminals and computer labs (mostly used by science, technology, engineering, mathematics and business students), some use of computers to produce student papers and reports. Environmental impact: Massive increase in power and paper use and introduction of significant electronic waste and significant investment in climate-controlled buildings for computers.

1980s – Most university students introduced to use of computers and development of word processing, use of decision support systems and expert systems by faculty and students, use of computer games and simulations, expansion of computer use to students in all majors (such as language labs). Environmental impact: Further increase in building space and power and paper use; however, significant reduction in space required for equivalent computer systems.

1990s – Complete scheduling by computers, use of personal computers by all students, labs with smart terminals or personal computers, faculty with personal computers, internet access becomes available to all. Environmental impact: Creation of massive electronic waste problem with fast obsolescence of each pc generation, no paper reduction experienced

2000s – Libraries move to mostly electronic access, class materials and student papers move to mostly electronic access, textbooks begin move to electronic versions, communications move mostly to email and other electronic means, large data centers become common. Environmental impact: Move to recycling electronic waste is begun (but with major recycling process flaws), energy use of data centers becomes significant, electronic industry moves to a leadership role in correcting supply chain recycling problems and becoming more efficient

2010s – Online class delivery systems become commonplace (even for face-to-face classes), online course management systems and online advising systems replace all paper-based systems, massive capacity data centers become commonplace. Environmental impact: Paperless class delivery becomes commonplace, student travel can be reduced significantly, need for large lecture halls and many other campus buildings eliminated, equivalent data centers dramatically reduce space and energy use.

3. ASU/ASU Online Business Model

3.1 Study Scope

ASU means the entire ASU enterprise complex, comprised of 18 major academic units (schools and colleges); (approximately) 83,000 students, 3,500 faculty, 4,000 staff; 5 physical campuses (with more under consideration) and the ASU Online "virtual" campus. ASU Immersive means ASU minus ASU Online, that is, the historic campus-based ASU. ASU Online means the ASU Online unit that "manages" ASU degree programs through the ASU Online platform.

For the purposes of this study, this greater ASU enterprise complex can be seen as a system that takes in enrollees and, using energy and other resources (natural, financial, production, etc.) as inputs and then produces outputs such as graduates and negative environmental impacts (in CO_2 equivalents), depicted at a high level in figure A (next page). Graduates, in turn, create positive socio-economic outcomes and impacts. ASU's overall net positive sustainability goal is enhanced by increasing the number of graduates, thereby increasing positive socio-economic outputs and outcomes, while simultaneously reducing the average resource consumption and negative environmental impacts required for each graduate produced. ASU Online can play a critical role in achieving ASU's overall sustainability goals as seen from this perspective. For this study, students pursuing undergraduate degrees were selected as the unit of analysis.

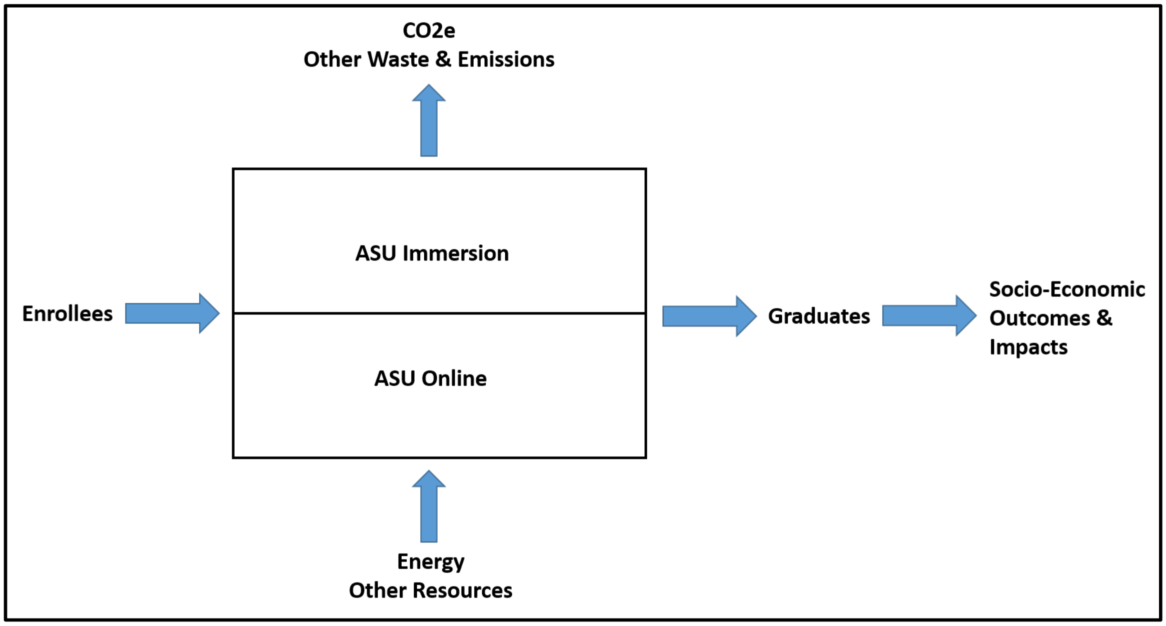

Figure A. The greater ASU complex

3.2 Online Education Market Trends

There is a major difference in market segments between classic immersive higher education and online education. Online education tends to serve a non-traditional student population in greater proportion than the more classic 18 to 25-year old student pursuing an undergraduate degree. These non-traditional students tend to be older and generally have full-time jobs, families and other responsibilities that make attendance at a full-time campus-based degree program difficult and often impossible. Most of these non-traditional students have previously attempted college one or more times and come to an online degree program with many credits applicable towards their degree.

Online education is in a process of recovery from an initial period of rapid expansion both nationally and globally that often resulted in a general impression that online education is of inferior quality to immersive education. These dilutions in the quality of education delivery, student support and faculty development, along with historic perceptions of the degree experience, have resulted in a persistent discernment that the quality of an online education is inferior to that of a campus-based education. An additional prevailing perception has been that new employees coming from an online education somehow make for an inferior, or at least less-prepared, worker.

These persistent perceptions of the quality of education are being mitigated, even reversed, by a number of factors. One such factor is the entry of major name-brand institutions of higher education, both public and private, into the market. Arizona State University with its ASU Online offering is one such high-profile public university. Penn State and the University of Maryland are two others who have entered the market in a major way. Columbia, Harvard and MIT are examples of private universities of high reputation experimenting in the market.

Another key factor reversing the quality perception is innovation. The last several years have been characterized by the very rapid, disruptive innovation taking place in the education market. Education technology (ed tech) has allowed business and pedagogical model innovation and continues to improve all functions of the online education enterprise, from content creation and delivery to course management, student support, and faculty development. Based on comments from the experts interviewed for this study, there is very little that can be done in the f2f classroom that cannot be done online. Conversely, anything that can be done in the online mode can also be done in the immersive mode. Physical science, engineering and technology courses and labs are one area cited as still being a challenge for online delivery, though technology continues to rapidly improve such standards. An example of this is the creation of "virtual labs."

As a result of the entry of educational institutions with a high reputation, the existence of a very large non-traditional student base, ongoing ed tech innovation and the changing personal cost/benefit value proposition to the student, the online education market is entering a new era of rapid growth.

Another key trend identified by many of our experts is the blurring of the boundary between online and immersive education. This is a result of a number of trends including the option of immersion students taking some of their course load online even though they are campus based. Another key element of this blurring is the emergence of the "flipped classroom". In this model, students do most of the following work online: view lectures, read/review materials, discuss content with other students and faculty, take quizzes and tests, and submit assignments. Time in the classroom is spent working on course work that includes both individual and team projects while under the mentorship of the teaching team. This model is not new but continues to grow as a key alternative to the lecture-oriented class model. This trend both enables the integration of immersion and online students, as well as gives rise to the need for a different kind of classroom space.

Lastly, the boundary between immersive and online education with respect to the adoption and use of new technology is bi-directional and highly permeable. New uses for existing technology and the discovery of new technology once successfully employed in either environment rapidly diffuses into the other. One result of this blurring is the technology intensities of immersive and online education are becoming nearly identical. As this trend continues, immersive students will use nearly as much ICT resources as an online student. This currently occurs to varying degrees depending on the course and instructor; however, in programs similar to ASU, the difference is generally minimal since the same instructor teaches the course in both settings using the same ICT platform.

3.3 ASU Sustainability

ASU business model choices are also taking place within the context of ASU's broader sustainability vision, goals and initiative. ASU's President Michael Crow is a leading visionary for sustainability in higher education. He envisioned and led the implementation of the ASU Julie Ann Wrigley Global Institute of Sustainability, which plays the role of coordinating research, education and solutions practices across the ASU enterprise. The first sustainability institute in the nation, it also houses the first School of Sustainability. He is one of a handful of university executives who created the American College and University Presidents' Climate Commitment (ACUPCC). ASU has an internal "University Sustainability Practices" that oversees initiatives to enhance and achieve sustainability of on-campus operations.

Dr. Crow has established broad and aggressive goals for ASU, as stated in its Strategic Sustainability Plan. Key goals include:

> Goal 1: Carbon Neutrality. Carbon neutral for Scope 1, 2 and non-transportation Scope 3 emissions by 2025; Scope 3 transportation emissions by 2035.
>
> Goal 2: Zero Waste. Eliminate 90 percent of campus solid waste from the landfill by 2015; reduce water consumption by 50 percent or eliminate 100 percent of campus water effluent by 2020.
>
> Goal 3: Active Engagement. Achieve 60 percent documented engagement by members of the campus community by 2015.
>
> Goal 4: Principled Practice. Integrate sustainability practice principles in 80 percent of campus operations and functions.

These aggressive goals are backed by detailed implementation plans, in-process projects and strategic partnerships. For instance, the energy services company, Ameresco, and resources think tank, Rocky Mountain Institute, are ASU's strategic carbon neutrality partners. Together, the three entities identify, plan and implement projects that will reduce ASU's carbon emissions and meet the carbon neutrality goal. Initiatives have resulted in such things as all new buildings and building retrofits being built to a LEED Silver or better standard, on-campus solar implementation of 25 megawatts and growing, aggressive recycling programs, student and faculty outreach and education programs and many more. Realization of these goals would clearly and dramatically reduce the environmental footprint of a student pursuing an education on campus.

3.4 The ASU Online Business Model

ASU classes are delivered in three formats: Course (f2f course taken by an Immersive student), iCourse (online course taken by Immersive students), and oCourse (online course take by an Online student). iCourse and oCourse sections are often combined into one overall section meaning that the delivery team is teaching ASU Immersive and ASU Online students simultaneously in the same course section within the same learning management system (LMS). This is one element of the ASU case study that supports our conclusion from interviews that the lines between immersive and online education are blurring. This enables us to make assumptions about the technology intensity of immersive versus online education in order to arrive at conclusions about the increase/reduction of environmental impacts of IT for online.

After the first five years of utilizing a different LMS for ASU Immersive (Blackboard) than for ASU Online (Pearson eCollege), ASU is migrating to a single platform for all courses, whether immersion or online: Blackboard. The same ICT infrastructure, including hardware, software and support services, is used to manage both the ASU Immersive and ASU Online production loads. It is also noted that since the same faculty serve both populations, significant differences in systems and software are not practical. Faculty will not tolerate the added personal time overhead of multiple course and interaction systems. In addition, the typical 18-year-old entering the immersive programs expects that all course materials and major interactions will be online. The result is the blurring of boundaries to such an extent that identification of specific use of ICT equipment and applications by degree programs is extremely complex and difficult. Attempts to identify specific online ICT were abandoned in this study. It also makes it very difficult to determine the per student requirement for ICT infrastructure leading us to make a general assumption on the relative technology intensities of immersive and online education for the handprint and footprint model presented in section 4.4.

The current ASU Online market focus was not necessarily an explicit choice, but one that presented itself as ASU Online grew. At first, some ASU personnel were concerned that ASU Online might "cannibalize" the ASU Immersive enrollment base. However, ASU and ASU Online currently address the two completely different markets discussed above. The traditional archetypical ASU Immersive student is 18-25 years of age, a full-time student and is either a campus resident or commutes within the Phoenix Metro Area. The campus-based socialization process is an important part of the education experience for this student.

The archetypical ASU Online student is a 31-year old married woman with 2 children working a full or part-time job. She brings an average of 60 credit hours into the online degree program, is not interested in the socialization process provided by the immersive experience, and has a very specific purpose for seeking a degree, usually to improve career outcomes. Most importantly, she typically would not continue with her degree to completion if the online option was not available to her. For this market segment, the keys are ease of access, engagement of the faculty, building of online community with other students, affordability and student support. ASU's recent announcement of its partnership with Starbucks, in which Starbucks will provide an online education toward a degree free of charge to a large segment of its employees, is an exemplar of this market. Anecdotally, most Starbucks employees interviewed in the press said they simply would not get a degree if this option were not open to them. 1,000 Starbucks associates registered in an ASU Online degree program in the first semester.

A critical aspect of the ASU business model is purposeful education innovation, especially technology-based innovation. This innovation includes the application of big data and data analytics for all functions, especially student recruitment, retention and support. Another example is the continual experimentation with ways to implement hard science, engineering and technology degrees. The first such degree to be offered is an electrical engineering degree that began in fall 2014 and is one of the fastest growing ASU Online degrees. All lab courses for this program will be virtual labs.

From an innovation perspective, ASU Online has resulted in the emergence of ASU's "EdPlus" initiative, which has become a primary innovation engine of ASU's higher education learning models. The ASU Online Provost leads EdPlus, including the Adaptive Learning initiative. The EdPlus initiative continually monitors 100-150 technologies for potential application in *both* the online and immersion environments. One key innovation from EdPlus is the emergence of a fourth type of course, the aCourse. This type of course utilizes adaptive learning technologies to enable a student to progress through the course on a path and pace that adapts to their current knowledge and skill level, as well as their learning style. aCourses are available in both online and immersion environments. This leads to a further blurring of the boundaries and reduction in the difference of technology intensity.

4. Discussion of Models

A series of structured interviews were conducted with a wide range of experts related to the ASU Online degree programs. Information from these interviews provided the content for developing three models and development of two key areas for output metrics related to completion of an ASU Online degree. Section 4.1 presents a summary of the stakeholders identified during these interviews. Social, economic and environmental value propositions suggested by the interviewees are then provided in Figure B. Section 4.2 presents the dynamic model of ASU undergraduate degree production envisioned for the future. Section 4.3 presents an overview of the social and economic benefits associated with having access to and then completing the ASU Online undergraduate degree program. Section 4.4 then presents a proposed model for calculating both handprint and footprint metrics related to the ability of students to complete a degree. Using available public data, some specific values are produced for the metrics.

4.1 Holistic Value Proposition

A given business model will result in a specific set of benefits to stakeholders. From a customer perspective, this is often referred to as a "bundle of benefits" which is directly related to the value proposition. The bundle of benefits, or value proposition, can be characterized for a given business model for all stakeholders in the value network. We have previously referred to this distribution of value capture as the Holistic Value Proposition (HVP) (O'Neill et al. 2009). This is also identified by Porter and Kramer (2011) as "Shared Value." The HVP is a good way to begin the analysis of net positive benefits from ASU Online and ICT in ASU Online. Figure B (next page) summarizes some of the key findings from the structured interviews by presenting a table showing the value proposition for the major stakeholders in undergraduate education. Twenty key internal and external experts related to the ASU online program were interviewed. Stakeholders identified are society, students, the academic institution, faculty, employers and the ICT industry. Key social, economic and environmental values are identified for each of the stakeholders.

Stakeholders	Social	Economic	Environmental
Society (Nation)	• Improved access to education •Increased education of general public • Improved social conditions of society with educated public	• Higher economic productivity with educated population • Increased wages for all members of a more educated public	• Increased opportunities to make positive environmental change with educated population • Decreased GHG emissions from transportation and building construction avoidance • Decreased road congestion and construction from commuting avoidance • Decreased urban sprawl from commuting avoidance
Online Students	• Improved access to education • Flexibility and freedom in school schedule • Eligibility for better jobs with degree • Better social conditions in all areas of life	• Increased lifetime earnings with degree • Higher net worth at retirement • Maintain income while attending school • Reduced spending on gas and vehicle maintenance from commuting avoidance	• Lower contribution of vehicle emissions from commuting avoidance
Academic Institutions Offering Online Education	• Access to long-distance collaboration • More diverse student set	• Access to new student market • Cost savings in energy and gas bills • Building construction avoidance	• Decreased GHG emissions from decreased campus use and building construction avoidance
Faculty	More experienced student set • Higher degree of flexibility and freedom in work • More diverse student set • Access to long-distance collaboration	• Reduced spending on gas and vehicle maintenance from commuting avoidance (although this is assumed to be a totally separate decision for the ASU case)	• Possibly lower contribution of GHGs from transportation avoidance • Possibly reduced vehicle use from commuting avoidance
Employers	• Happier employees • Increased education of employees	• Higher productivity associated with increased education of employees • Retention of employees who wish to pursue education Reduced absenteeism of employees	
ICT Industry	• Improved business reputation	• Expanded business opportunities •Marketing opportunities	• Enablement of carbon reduction through ICT system

Figure B. Holistic stakeholder value proposition

4.2. A Dynamic View: ASU/ASU Online 2015 - 2030

Next we consider the story of education innovation and its impact on the sustainability of higher education at ASU, nationally and globally. For the ASU case, the net positive position of IT in online education is changing dynamically due to a complex mix of factors. Figure C represents one such outcome of these dynamics. It is a somewhat idealized, best case scenario of the ASU complex if it meets its growth and operational sustainability goals. We discuss some of these factors following the figure. These factors will have the net effect of producing a graduate for a much lower environmental footprint than today. And, many more graduates will be produced. Use of ICT will be the key driver.

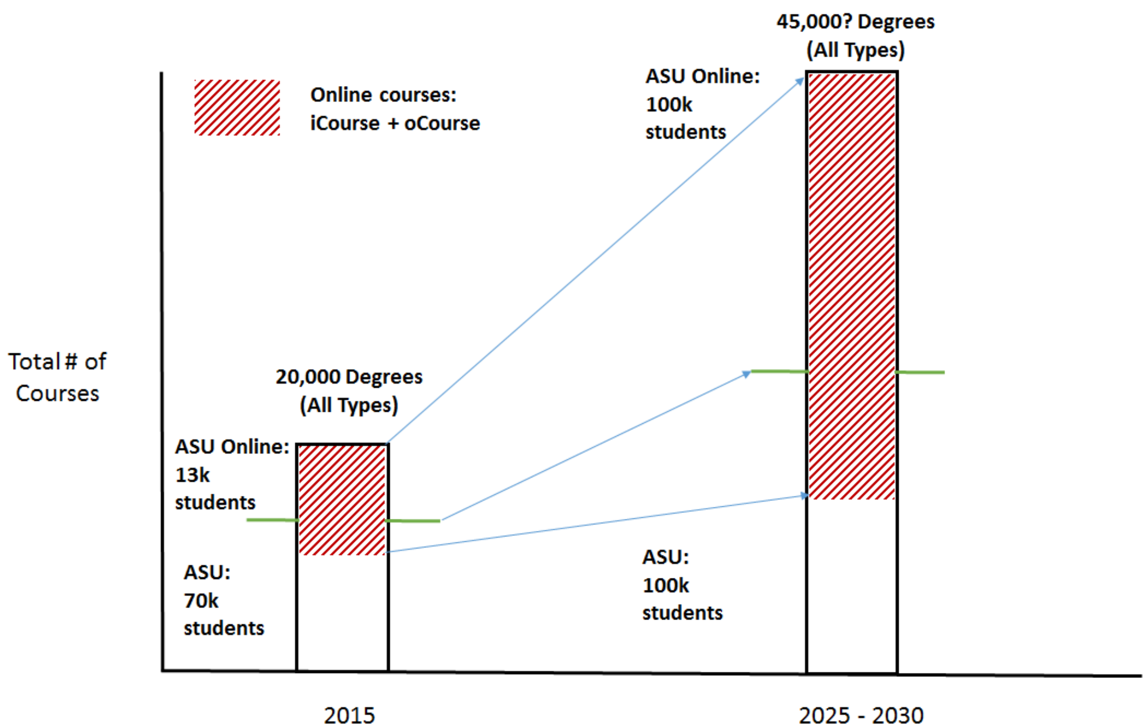

Figure C. Potential outcomes of the growth and evolution of the ASU complex

Both ASU Immersive and ASU Online will continue to grow, though ASU Online growth will be much more dramatic. Key interviewees estimate that ASU will hit the “100/100” mix sometime between 2025 and 2030. That is, there will be 100,000 students in the Immersive campuses and 100,000 students in the Online “campus.”

In terms of the total course load delivered by ASU, the immersion to online course mix will change dramatically. This will be due to the dramatic increase of ASU Online students, while simultaneously ASU Immersive students take a larger portion of their classes online. The ongoing, rapid evolution of education technology will enable the delivery of ever more degrees through the online channel, while simultaneously increasing the efficiency of delivery and support.

This growth will happen within the context of ASU's broader sustainability strategy comprised of climate neutrality, zero waste, zero wastewater and low hazardous material goals. ASU will continue to aggressively pursue these goals, including net zero energy without considering transportation by 2025 and net zero including transportation by 2030. Realization of these goals may mean that an on-campus student will have little or no environmental footprint. With society-wide improvements in transportation efficiency accompanied by ASU policy measures, even a commuting student may have little to no footprint. Ironically, an online student may actually have a larger personal footprint in their education process, due to personal lifestyle.

In addition to building use, proportionally fewer buildings per student will be required. However, it is extremely difficult to estimate the building requirement per student. Much of the built infrastructure is required to house the faculty required to teach ASU Immersive and ASU Online, as well as their research initiatives. The amount of building will also be affected by decisions as to where to locate student growth. Accommodation of additional students on the Tempe campus may require few new buildings. However, ASU may, within its strategic vision, decide to opportunistically build one or more new campuses, requiring more built infrastructure than utilizing existing campuses.

On all campuses, different types of classroom spaces will be required, due to the emergence of the flipped classroom and other evolutions in pedagogy, many enabled by ICT. In any case, new and retrofit buildings will continue to be built in a more environmentally sound manner, incorporating LEED, Net Zero and Living Building concepts.

Thus, from a longer term perspective, there will also be significant energy, carbon and other resource savings from more efficient transportation and dramatically reduced per student building construction and use. This will be supplemented by increased efficiency of ICT in the use phase, as the ICT industry continues to make improvements.

In this story of innovation, avoided carbon due to ASU Online is dramatically increased in this dynamic view. Additional major positive impacts are due to access and affordability. Simply put, many more people will attain a degree through ASU than would have without online delivery. The big impacts are the economic and social returns to a degree, which seem well documented, even though they may change/erode over time.

The longer-term net positive story is one of innovation in a dynamic, global market comprised of overwhelming needs to educate both traditional and non-traditional students in developed, emerging and developing countries. Online education may be our only hope for 9.5 billion people to get a quality education in a sustainable manner in the years approaching 2050.

One potential future research initiative is to develop a dynamic model to represent a range of future scenarios that depict these system dynamics, for ASU as well as other institutions of higher learning. Such a model could be used for decision support by policy makers and executives of institutions of higher learning.

4.3 Socio-Economic System Wide Effects

4.3.1. Impact of education on community

A key finding of this study, supported by the interviews, is that many, even most, ASU Online students would not get a degree if an online degree were not available. Access to education is one of the biggest contributions of ASU Online. Hout (2012) argues that the societal gain is more when more people are educated. It has been observed that the wages of high school students increased in places where the proportion of college graduates in the labor market increased (Moretti 2004). Everyone gained from the educated workforce. If education boosts collective productivity as well as personal productivity, then increasing educational attainment for a population might be a key causal factor in overall economic growth. In fact, estimated social returns to education might exceed private returns. This trend is observed in metropolitan cities, which gain from having educated populations (Lange & Topel 2006).

4.3.2 Impact of education on family, health, social capital and morale

Ellwood & Jencks (2004) found that college graduates are less likely to go through divorces than those who have no degree. They argue that education also has an impact on the number of children a family has. Although real life decisions are more complex and it is difficult to draw a direct causal relation, the timing of events strongly supports the inference that education increases the stability of marriages (Schwartz 2010).

There are also a number of studies that suggest that college education improves a person's general health (Mirowski & Ross, 2003). However, causality has been a difficult thing to prove. The relationship between getting a college degree and a healthier life is not direct; a number of social, behavioral, and biological factors stand between them. However, the general argument made by all the studies is that formal education improves a person's understanding of qualities and habits that promote good health.

Finally, research on happiness levels has often centered on the role of money in subjective wellbeing. However, sociologists have emphasized the role of education in happiness. Although there have been no attempts to establish causal linkages between education and happiness, Yang (2008) show that education differentials are robust with respect to happiness. People with a college degree are found to be happier than those without a college degree.

4.4 Net Positive: the ASU Online Handprint and Footprint Model

In developing this report, the research team utilized the Global e-Sustainability Initiative (GeSI) methodological framework as a guide to developing the carbon-focused environmental aspects (footprint) of the net positive statement. The framework was used to identify primary and secondary enabling and rebound effects. We also gave consideration to adapting the framework to express the socio-economic "handprint" aspects of the net positive statement. The study team will provide the report data in GeSI, along with observations on its applicability to this type of net positive analysis, at a future time. After identifying the enabling and rebound carbon effects, as well as socio-economic factors, the team made detail calculations of the net positive results. The detail behind the calculation of each net positive factor is explained in the Appendix. Figure D on the next page is a one-page representation of the model resulting from this methodological approach.

The net positive “handprint footprint” model represented in Figure D (next page) is a static snapshot model as of today. It tells the story of the net positive benefits received by a broad stakeholder network when a student chooses an online degree path and completes the degree. The negative impacts and positive benefits are estimated based on current conditions, such as energy mix, transportation efficiency, current research into the value of an education, and so on.

Figure D (next page) provides a summary of the factors included in the model scope. Initial data findings for the ASU Online case are also shown. When it comes to assessing the net positive impact of ASU Online, key factors included in the scope of the model are net ICT footprint of ASU Online and the potential social and economic handprint of students that are enabled to complete a degree.

The model quantifies handprint by including the expected additional average lifetime economic earnings as a result of attaining a bachelor’s degree, adjusted for a shorter remaining career span, and potential higher net worth at retirement. Potential benefits are based on reported research findings regarding the lifetime value of completing an undergraduate degree relative to not completing the degree. Broader social returns are largely in terms of social services avoided and/or contributed. The net positive socio-economic impact per degree produced is conservatively estimated at $545,000. The model also identifies the overall system-wide social impacts of attaining a college degree.

For the footprint, the model focuses on quantifying carbon dioxide equivalent (CO_2e) emissions. Other environmental impact categories such as paper reduction, water use, and building construction were only briefly considered during this study and no attempt to formally quantify them was made. The factors considered for footprint calculation in this study include increases in direct ICT emissions, net new data center construction and ICT equipment, telecommuting savings and reduced construction and use of campus facilities. The net positive impact on emissions is conservatively calculated at 28.3 t CO2e/degree produced[1].

[1] t CO2e: metric ton carbon dioxide equivalent; fte: full-time equivalent

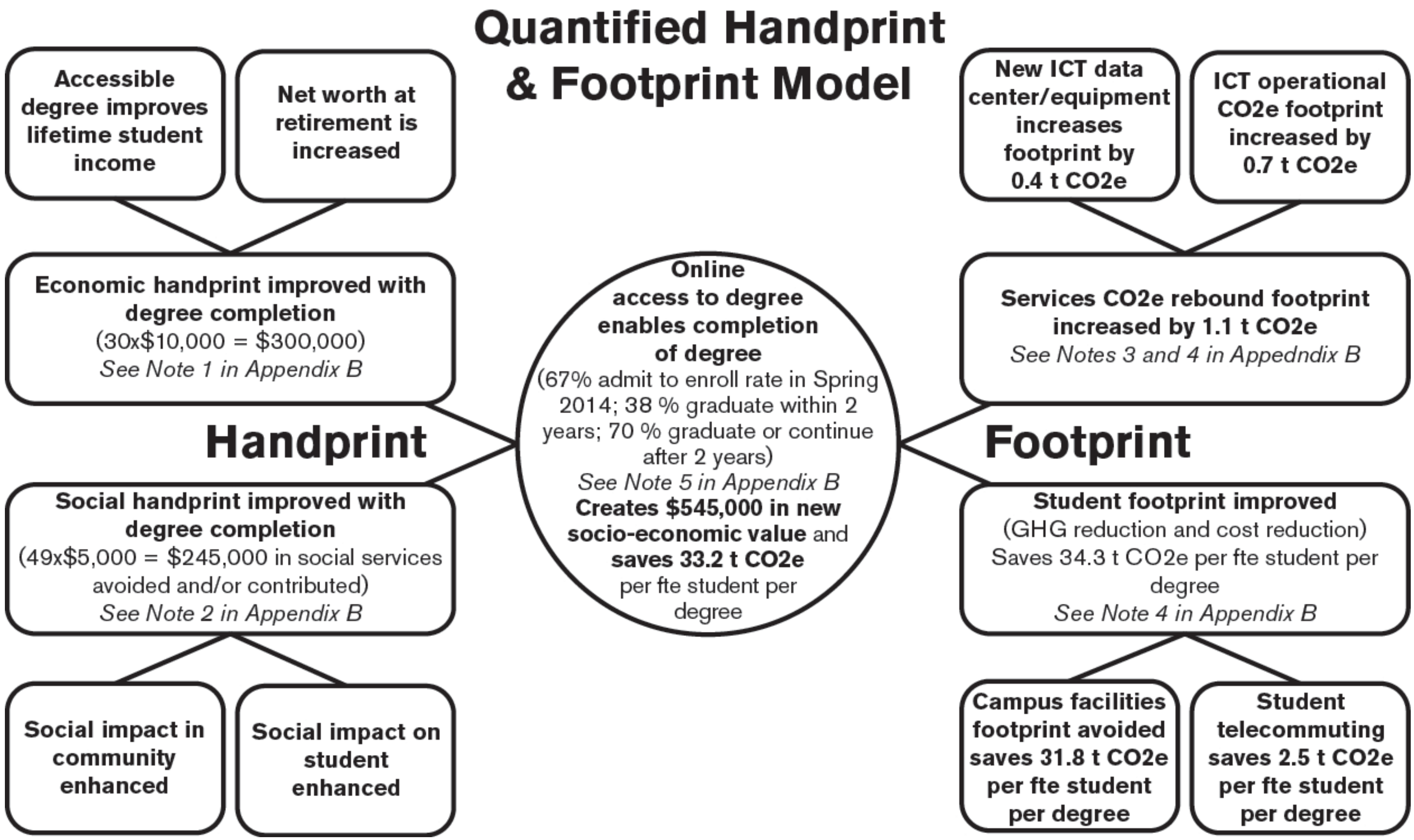

Figure D. Quantified handprint and footprint model

5. Conclusion

As Phil Regier, Executive Vice Provost and Dean of ASU Online since its inception points out, "No higher education institution has all the answers, but colleges and universities (and public institutions in particular) are increasingly becoming part of the solution by focusing on partnerships with external companies and other campuses, placing their independent analysis and innovation in service to their students and prospective students." (Regier, 2014) This study does not attempt to promote technology as a one-stop solution to problems.

Despite its uncertainties and limitations, and challenges like affordability and job availability, the study does answer the question as to whether or not ASU Online education model has a net positive effect. The quantification of relevant effects and processes indicates a definitive net positive effect. The study provides a discussion ground for education institutions to create pathways that will lead to the success of nontraditional students. The research presented in this study shows that education yields personal, environmental, and social returns on investment. Education pays off because, in addition to nurturing specific skillsets, it adds value. In the nation's colleges and universities, students acquire new skills and new perspectives that make them better workers, life partners, and citizens. The universities do not merely identify the young people who fit the desired profile; they disseminate skills and foster values.

Education makes life better. People with more education earn more money, lead healthier lives, divorce less often, and provide more support to the functionality and civility of their societies than less educated people do. There is substantial evidence to prove that education plays a significant role in improving peoples' lives in ways that matter later in life. Inequality of educational opportunity persists, however it would be even more unequal without online schools. This is a strong motivation factor for providing online education: to create access for people who would not have gotten a degree if an online degree were not available.

5.1 Key Findings

5.1.1 ASU Online is a key innovation driver at ASU

One of the key findings of this study for the ASU case is that ASU Online has become not only an alternative to underserved, non-traditional students to get a degree. It has become the primary innovation engine for evolving ASU's model of higher education. As noted, the Vice Provost of ASU Online leads the ASU EdPlus initiative that is incorporating adaptive learning into curricula, continually monitoring and experimenting with 100-150 technologies and providing advanced faculty development in the use of technology tools, which can be utilized in both the online and immersion environments, and rapidly diffused across the boundary.

To be sure, ASU Online is not the only source of education innovation in ASU. But, it has become a primary and coordinating unit for purposeful education innovation. This role is closely related to the following key finding.

5.1.2 ASU online is a critical component of sustainability at ASU

Another key finding of this study, and one more pertinent to its purpose, is that ASU Online has become a significant component of ASU's sustainability strategy. This was not necessarily planned. When asked about the sustainability impacts of ASU Online, almost every ASU person said something like "I hadn't thought about it from that perspective." Much of ASU operational sustainability efforts have been focused on campus operational sustainability. ASU Online was created primarily to broaden access and affordability, and to provide an additional revenue stream to ASU, much needed in the wake of state cutbacks that happened across the country during the Great Recession.

But, it is clear that ASU Online, with its dramatic growth aspirations, will become a significant part of the ASU sustainability story: more degrees leading to more socio-economic impact for a smaller environmental footprint per degree.

5.1.3 The net positive contribution of ICT to online education

In the end, the contribution of ASU Online to the net positive position of the ASU complex is substantial and is based almost entirely on increased access and affordability. Simultaneously, it is lowering the environmental footprint required to produce an undergraduate degree.

The reader may have noticed throughout our analysis that we have conflated "the net positive contribution of ICT to online education" with "the net positive contribution of online education to education overall." That is the case, because it seems to be the proper focus within the ASU case.

However, we can also comment on the original question. As one of our reviewers commented, the contribution of ICT to online education in the ASU case could be arrived at in one of two ways. One could take the position of "no ICT, no online education" and, thus, no benefits. In this perspective, 100% of the net positive position of online education is due to ICT. Alternatively, one could propose an allocation method, such as the percentage of total costs of the online education enterprise due to ICT infrastructure, to determine the proportion of benefits due to ICT. For the time being, we leave this question for the reader to ponder.

In any case, within the context of the ASU study, the real story is the way in which ASU Online is affecting the broader ASU complex. The role of ICT in this affect cannot easily be disaggregated from the complex, interrelated set of business model choices made in creating and evolving ASU Online. The important point is that ICT is enabling innovation in education in general, and in online education specifically. The ratio of positive benefits of producing a college graduate to the resources required to do so, including emissions, is growing larger quickly due to the maturation of online education and the dedication of higher education institutions to making it so. ICT plays a central and critical role.

5.2 Limitations and Further Research

The six most significant limitations of the current ASU case study (and suggested phase 2 research project steps) are presented in this section. It is the opinion of the current research team that results will not change dramatically with further research; however, further research should be done to provide greater understanding of and confidence in the results of the current case study and to be able to make estimates for a broader set of university campuses. Universities conducting significant online undergraduate programs and also signatories to the ACUPCC would be the likely broader set. Public data would be more readily available for these universities. Finally, as noted earlier in this report, development of a dynamic model of online education could be useful to policy makers and executives of institutions of higher learning.

Limitation 1: The increased investment in ICT systems to accommodate online and the increase in GHG production from added ICT systems for online are not thoroughly identified in this study. Because of the use of the same platforms for both immersive and online students, any statements about additions because of online are somewhat ambiguous estimates. Interview results suggested that the difference between immersive students and online students is simply the extent and frequency of use rather than different hardware and software. The same faculty teaches in both online and immersive for this ASU case study.

Future research: Steps in a follow-up research project would include gathering and analyzing appropriate samples of use data. This would involve first identifying a representative set of classes taught in both immersive and online undergraduate programs. Second, a representative random sample of students from each class chosen in step 1 would be identified prior to the start of a semester. Third, actual user data would be extracted from the ICT systems for each of these students for the entire semester. Finally, statistical estimates of differences in use would be made and then converted to implications for space, equipment and other resource needs to meet the increase in use found for online students. The increased resources could then be converted to added investments required by online and additional ICT footprint from online. This future research project was beyond the scope of this study.

Limitation 2: The quantification of GHG savings from reduced campus infrastructure needs is composed of an assumption about the annual operating savings as a % of the reported GHG impact of the campus and a very high-level estimate of the net benefits from classroom construction avoidance.

For the operational perspective, we work from the ASU report to ACUPCC covering the 12-month period beginning July 1, 2012 (http://rs.acupcc.org/ghg/3024/):

" … ASU worked with Sightlines, LLC to identify the various GHG sources throughout campus … Inventory data was collected from a wide variety of campus sources for seven primary categories of greenhouse gas emission activities:

- Energy production and use (including purchased and site-generated utilities)
- Commuter transportation

- ASU vehicle fleet usage fuel purchases
- University Business Travel and Study Abroad travel
- Municipal solid waste production and disposal
- Usage of nitrogen-containing agricultural fertilizers
- Fugitive emissions of halogenated refrigerants

… The primary source of ASUs GHG emissions is the production and use of energy on ASU's Tempe campus, West Campus, Polytechnic Campus and the Downtown Phoenix Campus. … ”

From ASU reports to ACUPCC (see http://rs.acupcc.org/ghg/3024/), the carbon footprint per student per year in 2012 can be estimated at 4.3 t CO2e. If one assumes that an online degree student avoids 75% of the campus facility infrastructure need, then a fte online student completing the last two years of college at an online program might be estimated to save 6.5 t CO2e for the two-year period (4.3x 2 x 0.75).

For estimating construction avoidance, the calculation is quite complex, consisting of a number of variables that could have wide variation. This is explained in detail in the Appendix. Estimates of this net benefit, after subtracting out the embodied carbon of new data center construction and ICT equipment to support the production of ASU Online undergraduate degrees, range from 25 t CO2e per degree to 73 t CO2e per degree. For the purposes of this study, we conservatively select the low estimate. The difference in these estimates yield significantly different results, when considered over tens of thousands of degrees to be granted during the coming decades.

Future research: Steps in a follow-up research project would include validating the assumptions stated above for both operational and construction scenarios. Further exploring the long-term upstream supply chain effects of not building additional campus buildings and infrastructure and identifying upstream ICT carbon output could yield more accurate estimates of these long-term upstream supply chain effects.

Limitation 3: Initial findings regarding enablement of degree completion are based on a limited sample of cohorts that started the ASU Online undergraduate degree and interview information gleaned from the ASU experts. Interviews are overwhelming in suggesting that most of these students would not have enrolled or even completed a degree without this opportunity; however, students have not been sampled to verify student perception of these issues.

Future research: A follow-up study might use survey or structured interviews to gather more complete information about the demographics and perceptions of the student base in the ASU Online degrees. Additional and larger cohorts could be added to the graduation and admit to enroll statistics reported.

Limitation 4: Initial suggestions about lifetime income and lifetime social impacts are based solely on the many continuing studies that exist on the impact of completing a college degree versus having some college courses completed.

Future research: Although existing sources of data for these handprint economic and social factors may prove to be adequate, a follow-up study would explore these sources in greater depth. In addition, some primary data might be collected and some surveys or interviews might be developed for graduates of the ASU Online program.

Limitation 5: This is a single case study. Although many other public universities may have embarked on similar programs and have similar results, it will be hard to generalize to this broader base at a national level without conducting some additional case studies and/or gathering a limited set of data (mostly from public documents) for a larger sample of universities.

Future research: A follow-up study would add case studies and/or gather data for a larger sample of universities. As previously noted, universities conducting significant online undergraduate programs and also signatories to the ACUPCC would be the likely broader set.

Limitation 6: Other environmental factors that were briefly discussed during this study, then excluded from it include: use of water on campus; disposal of solid waste from campus to landfill; water runoff and sewage waste from the campus; food supply chain issues.

Future research: For the ASU case and for most universities committed to the American College and University Presidents' Climate Commitment (ACUPCC) initiative, any major differences in these other factors are temporal as ASU and these other campuses move toward goals such as zero waste to landfill. Many minor factors that have some potential for differences are simply not relevant factors for analysis. For example, paper consumption may be only slightly higher for immersive programs. Since immersive classes at ASU also provide all materials through Blackboard and since the decision to use a paper or electronic text is the same decision for either online or immersive, the only minor increase in paper usage for immersive programs may be in the use of paper for some tests. One should note; however, that some tests may be given for online courses in a supervised face-to-face setting to discourage possible student fraud. The use of ICT technology for individual classes has become totally blurred at this point.

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Appendix: Quantified Model Notes

(1) The research-based finding that a college degree adds 20% increased lifetime earnings above some college completed was used to estimate $10,000 average per year increased income times 30 years. This also is based on the ASU demographics (31 average age with 60 average college credits). If this student finishes by age 35 and works until 65 at a 20% higher income above $50,000, you get $300,000 extra lifetime income. This is a conservative estimate (see https://georgetown.app.box.com/s/cwmx7i5li1nxd7zt7mim). Using a 33-year career rather than a 40-year career that this Georgetown study uses would yield an estimate of $459,000 (0.85 x $541,000). In addition, from Hout, M. (2012), Social and Economic Returns to College Education in the United States, *Annual Review of Sociology*: "The median net worth of people approaching retirement with a Bachelor's degree is four times higher than those with only a high school diploma."

(2) The research findings discussed by sociologist Michael Hout from Berkeley suggest a myriad of social costs avoided by having a college education such as higher incomes even for others in communities, better health for those with college degrees, and fewer divorces and thus fewer people below poverty levels. This was arbitrarily put at $5,000 impact per year for 49 years. Based on Social Security Administration data, average life expectancy for a 31-year old male today is 82 years and female is 86 years (Average = 84 years; 84-35=49 years).
See Hout, M. (2012), Social and Economic Returns to College Education in the United States, *Annual Review of Sociology*. From the abstract for the paper: "A smaller literature on social returns to education indicates that communities, states, and nations also benefit from increased education of their populations; some estimates imply that the social returns exceed the private returns." The $245,000 social return may also be a conservative estimate. Hout is now at NYU.

(3) Units are per student online degree requiring the equivalent of two years of credits (60 credits) since incoming online students have an average of 60 credits completed. Assuming that the ICT footprint per BAU student is 25% of the campus footprint, the ICT footprint per BAU student is 2.2 t CO_2e (4.3x2x0.25). Also assuming an increase for online students of 30 %, the rebound effect is 0.7 t CO_2e. See the ASU University Technology Office Strategic Plan at https://uto.asu.edu/files/ASU-UTO%20Strategic%20Plan%202014-2018%20[Final]_0.pdf for a better understanding of the ICT issues. Based on interviews with experts, the research team estimates that the 30% increased ICT use is a good estimate; however, an actual use difference study is needed to determine a better estimate. It is estimated that this difference would currently range from 10% to 60% depending on the program and university situation. This difference will become much smaller in the future as delivery methods continue to merge and blur across immersive and online systems

(4) a. From the BT case in the GeSI report titled "Evaluating the carbon-reducing impacts of ICT: An assessment methodology," p.76: "CO2e/carbon dioxide equivalent (ITU): The amount of CO_2 emission that would cause the same radiative forcing as an emitted amount of a well-mixed greenhouse gas, or a mixture of well-mixed greenhouse

gases; used as the standard for reporting emission reductions in this report."
Commuting savings for one student completing an online degree may be calculated by **multiplying the EPA estimate of metric tons CO_2E /mile (4.20×10^{-4} metric tons** from http://www.epa.gov/cleanenergy/energy-resources/refs.html on October 14, 2014**) by an estimate of the average commuting miles avoided by a student completing an online degree** (miles per trip x number of trips x number of courses). (20 miles x 15 trips x 20 courses) x **4.20×10^{-4} metric tons CO_2E /mile = 2.52 metric tons CO_2E.**

b. From ASU reports to ACUPCC (see http://rs.acupcc.org/ghg/3024/, the carbon footprint per student per year in 2012 can be estimated at 4.3 t CO2e. If one assumes that an online degree student avoids 75% of the operational use of campus facility infrastructure, then a fte online student completing the last two years of college at an online program might be estimated to save 6.5 t CO2e for the two-year period (4.3x 2 x 0.75).

c. Estimating the per degree impact of campus construction avoidance is highly complex, with several variables that cause significant variation in the resultant amount of carbon savings depending on the values assigned to them. Throughout the following calculation we take the most conservative approach to valuing each variable. The savings can be estimated as (square footage of new building construction avoided per student * embodied energy per square foot * carbon conversion factor of embodied energy).

To arrive at square footage of new building construction avoided per student we assume that only new classroom space will be avoided. This does not include instructional lab space, as few current ASU Online degrees offer lab courses. From the ASU website "Campus Data Sheet" https://fdm-apps.asu.edu/UFRM/CDS/ current classroom space is 742,956 sq. ft. We divide this by 70,000, the number of Immersive students, to arrive at 10.61 sq. ft. of classroom space per student. We assume that classrooms are currently at 80% capacity, giving us 8.49 sq. ft. required to serve each Immersive student, thus giving us the per student construction avoidance for an Online student.

We arrive at high-low estimates for the embodied energy for construction of educational space from two sources: 1) in an e-mail, a representative of an architecture/engineering firm who participated in the construction of ASU's most recent LEED building consisting of lab, office and meeting space, estimates the embodied energy of their average construction of university facilities at 2,100 million BTUs (MBTU) per square foot, and 2) Stein (1978) arrives at an estimate of 1,700 MBTU for education construction. We select the low estimate for computing savings.

We must choose a reasonable, conservative energy mix. For the purposes of a high level estimate, we choose a value between the most carbon intensive energy and the least intensive. From the web site of the Energy Information Agency, coal has the highest at 0.104 t CO2e per MBTU and natural gas has the lowest at 0.053 t CO2e. We also calculate an "average" mix by dividing the total tons of carbon emission by the total

MBTU of energy consumed in the U.S. For 2014 this value is 0.08 t CO2e per MBTU. In order to be conservative in our estimate, we select the lowest of these values.

The original formula thus give us 632 t CO2e avoided per student over the lifetime of the space (8.49 sq. ft. * 1,700 MBTU/sq. ft. * 0.053 t CO2e/MBTU). We assume a 50 year useful life of the space. Once again, this is conservative. Not so much because of the relatively long life chosen, since university buildings are, indeed, often in service for this length of time. But, because we ignore any additional embodied energy amounts resulting from ongoing capital improvements over the useful life of the building, of which there are typically many. We continue with 60 hours to complete the typical online degree that would normally take 2 full years to complete. Thus, we divide 632 by 50 to arrive at the annual savings and multiply by 2 to arrive at 25.3 t CO2e per ASU Online undergraduate degree student of carbon savings due to new classroom construction avoidance.

Adding the operational savings of 6.5 t CO2e arrived at in 4b above avoided construction amount, we arrive at a total savings per student of 31.8 t CO2e in avoided campus building infrastructure, including both initial construction and ongoing operations.

We believe this to be a highly conservative estimate. We have taken a conservative approach in assigning variable values throughout this calculation. Using more “median” values leads to much greater net impact. For instance, using the average of the high and low estimates for MBTU per square foot of construction (1,750) and using an “average” energy mix for t CO2e per MBTU (0.08) yields a net savings estimate of 46.6 t CO2e per degree.

To count both sides of the ledger, we must subtract from this benefit the increased amount of embodied carbon in net new data center space and of ICT equipment required to support an online student. ASU ICT personnel report that total square footage of all data centers required to support the full 83,000 students at ASU (Immersive + Online) is 7,865 sq. ft. This includes all ASU and outside vendor space housing computing equipment required to support the student population. We assume the space it is 80% utilized. This yields 0.08 sq. ft. per student. To continue in a conservative manner, we select the higher estimates for MBTU/sq. ft. (2,100) and for t CO2e/MBTU (0.104). Using the same useful building life and degree time requirements, this yields 0.4 t CO2e per student for new data center construction.

ASU ICT personnel reports that 541 ICT devices are required to support delivery of all course materials. We assume all devices have at least the embodied GHG profile of a rack server. A 2005 Dell PowerEdge EMU3710P71 rack server was reported to have embodied carbon of 383 kg CO2e (Teehan Kandlikar 2013). We assume rack servers have increased in embodied carbon since the 2005 models, and conservatively assume 500 kg CO2e per server. Assuming the same allocation breakdown for Immersive and Online students, the capacity parameter of 80% that we used for facilities and a 3-year useful life for the server, we arrive at 0.0017 t CO2e of additional embodied carbon per

ASU Online student. This is not significant to the calculation of total increased carbon from new infrastructure incurred as a result of a student choosing the online path.

Adding the net new building and ICT infrastructure to the increased operational footprint, we arrive at a rebound effect of 1.1 t CO2e per online student. Subtracting this from the reduced footprint due to avoided construction and travel, we arrive at a net savings of 33.2 t CO2e per online student. Again, we have been conservative throughout our choices of parameters and estimates. Savings could be as high as 70+ t CO2e per online student.

d. Although online students do all of their coursework away from campus, it is estimated that there will be no increase in energy usage at home or elsewhere. These more mature students with families and jobs will not have any additional impact away from campus relative to taking night classes at a university. They use their own computers anyway and their families will not change power usage habits because of the degree-seeking member of the family.

(5) a. The estimate of 67% for the admit-to-enroll rate is from the Phil Regier article (**Using Technology to Engage the Nontraditional Student** via EDUCAUSE Review). Based on data provided by ASU Online for three cohort groups from 2010 and 2011, the graduation and retention estimates are:

3 cohorts 2010-2011	Initial Population	Yr. 1 grad	Yr. 2 grad	Still enrolled	Not enrolled	Must reapply
%	100%	16%	22%	23%	9%	30%
Cumulative %		16%	38%	60%	70%	100%
Credits Taken		30	60	80	84	45

b. The estimate of 20 courses as the average number of courses taken per student completing the ASU Online degree is based on using the graduation and enrollment values from the table in 5a to compute a number of credits completed by the students represented by the three cohorts above. Assuming that all of the students not needing to reapply eventually graduate and assuming that students that must reapply still take an average of 45 credits, the estimates of the credits taken for each of the categories are noted in the table above. Multiplying the % by credits and adding, the total number of credits is computed as 60 (.16x30 + .22x60 + .23x90 + .09x84 + .30x45). The estimate of 20 courses is computed by dividing 60 credits by 3 credits per course.