Next Generation Learning-Centered Environment for Architecture, Engineering, and Construction (AEC) Education

(Working Draft)

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Disclaimer:

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Workshop Report
(Draft)

BACKGROUND

In 2020, the National Science Foundation (NSF) published a report entitled "STEM Education for the Future: A vision report." The report discussed the guiding questions, priorities, challenges, and actions of STEM education to maintain the nation's leadership in science and technology discovery and to include all Americans in the innovative economy. The rapid social and technological changes require a new vision related to the ecosystem of STEM education [1]:

> "All citizens can contribute to our nation's progress and vibrancy. To be prepared for the STEM careers of the future, all learners must have an equitable opportunity to acquire foundational STEM knowledge. The STEM Education of the Future brings together our advanced understanding of how people learn with modern technology to create more personalized learning experiences, to inspire learning, and to foster creativity from an early age. It will unleash and harness the curiosity of young people and adult learners across the United States, cultivating a culture of innovation and inquiry, and ensuring our nation remains the global leader in science and technology discovery and competitiveness." [1]

The NSF's vision calls for an inclusive educational ecosystem to provide equitable outcomes for all learners, foster an ethical and future-ready workforce, and utilize emerging technologies to enhance teaching and learning.

Meanwhile, developments in the built environment significantly impact the natural environment and human societies. Today, about 83% of the US population lives in urban areas. According to the US Census Bureau, the US population will grow to 389 million in 2050 from 326 million in 2017 [2]. At that time, the urban population will increase to 89% [3]. As the population grows, the demand for increased infrastructure services will pressure the natural environment, leading to unsustainable land-use change and scarcity of food, energy, and water resources.

The AEC industry constantly seeks innovative and sustainable solutions to create healthy and inclusive built environments while battling climate change, bridging social inequity gaps, and embracing technological advancements to counter these effects. In particular, emerging technologies associated with the fourth industrial revolution, featuring high connectivity, increased data and computational power,

effective human-machine interaction, intelligent analytics, and advanced engineering [4], will likely affect many aspects throughout the lifecycle of construction projects. These grand challenges are compounded by unique issues facing the AEC industry, such as labor shortages and an aging workforce, low representation of women, high suicide rates, high occupational hazards, the need to reskill or upskill the existing workforce, an outdated apprenticeship model, and misconceptions about the construction industry. Therefore, the AEC education communities are at a critical juncture to support the industry by producing a competent future workforce capable of transforming the AEC industry following the fourth industrial revolution (4IR or Industry 4.0).

While seeking more effective solutions to traditional challenges, such as collaboration with industry partners for AEC curriculum enhancement and integration, the AEC education communities are facing new challenges. The new challenges are caused by complex social, technological, economic, environmental, and political factors [5], for example, the increased need for remote learning, the widening of the digital divide, the increased use of learning technologies, the demand for new/different workforce skills, and the urgent need to address global warming and sustainable development. These new challenges require the AEC education communities to make systematic changes to their current practice. In particular, the potential of emerging technologies for creating new opportunities to improve AEC education and the impact of such technologies on AEC curricula, the learning environment, and digital equity are still under-explored. A systematic investigation into the relationship between humans, learning, and technology in varied social contexts is still in the exploratory stages for AEC education, especially after the COVID-19 pandemic, which had a tremendous impact on the status quo. It needs to be noted that technology-enabled learning environments can be a double-edged sword. For example, online learning may improve accessibility and create digital inequity (e.g., [6]). A recent report [7] shows that a significant percentage of college students, about 16%-19%, had access difficulties, including hardware and internet connections. The problems mainly affected students from low-income, black, Hispanic, or rural families. In addition, digital literacy [8] is associated with digital inequity among college students. To prepare a future-ready AEC workforce, the AEC community must address these traditional and new challenges effectively. Thus, a national conversation must create a shared vision of the next-generation learning-centered environment for architecture, engineering, and construction (AEC) education.

INTRODUCTION TO WORKSHOPS

A two-workshop series was organized in collaboration with the Architectural Engineering Institute (AEI), an institute under the American Society of Civil Engineers (ASCE), and multiple divisions within the American Society for Engineering Education (ASEE), including the Architectural Engineering, Civil Engineering, Construction Engineering, Environmental Engineering, Minorities in Engineering, and Women in Engineering to explore synergies and opportunities for inclusive engineering education practices within the built environment. The main expected outcome was a shared vision of the next-generation technology-enabled learning-centered environment and a roadmap for research and implementation. This project focused on the needs of key stakeholders (i.e., students, faculty, administrators, AEC programs, and AEC industries), the challenges facing the AEC education communities, and solutions. Accordingly, the four themes of the workshops were 1) AEC Curricula and Industry Practice, 2) Interdisciplinary Education, 3) Technology and Learning, and 4) Digital Inequity. The project was intended to create a pathway to reflect on new learning strategies, new technologies, and future industry and societal needs in AEC curricula, thus producing a more adaptive AEC workforce.

The project's central focus is on the relationship between stakeholders in AEC education, technology, and lifelong learning (Figure 1). Human stakeholders in this research project include undergraduate AEC students, faculty, and practitioners. Technology refers to information and communication technologies, which can be a learning subject or an enabling factor in the learning environment. Lifelong learning refers to skills such as problem-solving and critical thinking that students gain in postsecondary education. And that can effectively support their training and learning needs in their professional and personal lives after graduation.

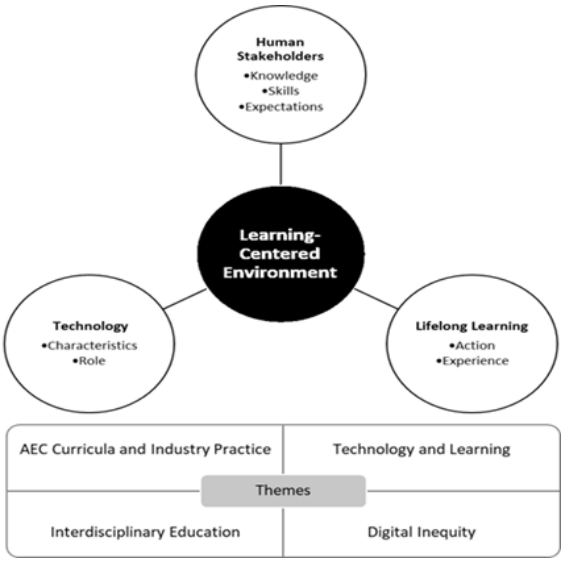

Figure 1: Focus of the Project

The first workshop was an online event from November 15 to 17, 2021. The objective was to identify the needs of the AEC education community, the challenges facing the community, and proposed solutions. Workshop 1 included a keynote by Dr. Medina-Borja, four topical presentation sessions (three presentations per session on a theme), an industry discussion panel (professionals from AEC industries and a professional construction organization), and breakout sessions. The breakout sessions were audio recorded. The second workshop was held from June 24 to 25, 2022, in Minneapolis, MN preceding the annual ASEE conference. Workshop 2 is a consensus-building process to create a shared vision and a roadmap. In addition to a keynote by Dr. Medina-Borja, group discussions and consensus-building sessions were the main activities of the workshop. Applying the Six Sigma SIPOC approach [9][10], a professional facilitator affiliated with Metro State University led the workshop process.

Table 1: Demographic information of participants

Categories	**Workshop 1**	**Workshop 2**	**Total**
Total number of participants	37	30	63
Field of Expertise:			
Architecture	5 (13.5%)	6 (20.0%)	10 (15.9%)
Engineering	14 (37.8%)	8 (26.7%)	21 (33.3%)
Construction	11 (29.7%)	9 (30.0%)	20 (31.7%)
Education	7 (18.8%)	7 (23.3%)	12 (19.1%)
Type of Institution			
Academic (R1)	27 (73.0%)	26 (86.7%)	49 (77.8%)
Academic (non-R1)	6 (16.2%)	4 (13.3%)	10 (15.9%)
Industry	4 (10.8%)	0 (0.0%)	4 (6.3%)
Affiliation			
Instructor/Designer	1 (2.7%)	2 (6.6%)	3 (4.8%)
Assistant Professor	12 (32.4%)	13 (43.3%)	25 (39.7%)
Clinical Assistant Professor	1 (2.7%)	1 (3.3%)	2 (3.2%)
Associate Professor	7 (18.9%)	6 (20.0%)	12 (19.0%)
Professor	10 (27.0%)	7 (23.3%)	15 (23.8%)
Industry Practice	4 (10.8%)	0 (0.0%)	4 (6.3%)
Other	2 (5.4%)	1 (3.3%)	2 (3.2%)
Gender			
Female	21 (56.8%)	12 (40.0%)	29 (56.0%)
Male	16 (43.2%)	18 (60.0%)	34 (54.0%)
Minority Serving Institution	2	2	3

The first workshop had 37 participants (17 presented in several sessions while participating in breakout sessions). The participants' fields of expertise included 14% architecture, 38% engineering (civil, mechanical, etc.), 30% construction, and 19% education (education science, engineering education, etc.). The second workshop had 30 participants (of which eight were from the first workshop), with fields of

expertise of 23% architecture, 31% engineering, 19% construction, and 27% education. The demographic information of the participants in both workshops is shown in Table 1.

Between the two workshops, the outcomes of Workshop 1, including the needs of the AEC education community, the challenges facing the community, and proposed solutions, were structured to create a questionnaire. Workshop 2 participants were asked to fill out the questionnaire before the event. Likert scales, 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree), were applied to elicit participants' degree of agreement with the identified needs, challenges, and solutions. The purpose of the survey is to prepare the participants for Workshop 2 and help organizers to design workshop activities. A total of 21 participants completed the questionnaire.

This report includes the combined outcomes of the two workshops, organized according to the four themes. Participants' views on the current status, challenges, and actions for each theme are summarized. The Appendix section contains additional materials concerning the two workshops.

AEC CURRICULA AND INDUSTRY PRACTICE

The human-technology frontier in AEC workplaces is changing in many fundamental aspects. Thus, it is crucial to answer questions essential to shaping the future of AEC education, e.g., what are the gaps between AEC curricula and industry practice, and what is the role of emerging technologies in creating and closing these gaps?

Current Status

Fragmented and disintegrated can best describe the AEC curricula and their relationship with the industry. First, the existing setup of AEC curricula, a legacy of industrial revolution 2.0 to a large extent, focuses on specialization and does not encourage collaboration among architecture, engineering, and construction disciplines. Secondly, major gaps between AEC curricula and industry practice exist. Problems, in reality, are complex; however, such problems are often tamed when presented to students. For example, the course assignments in engineering education often do not resemble the problems in the real world. Thirdly, according to the feedback of industry panelists, while many AEC schools and departments benefit from sustained communication and dialogues with industry partners such as their industry advisory boards, trends and changes in the AEC industries are not reflected in many AEC curricula in a timely manner. Finally, the current accreditation of AEC programs has a strong disciplinary focus. The role of accreditation in shaping future AEC curricula is not fully explored with respect to fostering AEC curriculum integration, industry-academia collaboration, disciplinary and cross-disciplinary communication skills, and fundamental skills and knowledge to deal with ever-changing technological progress.

Challenges

Bridge gaps between AEC curricula and industry practices: Create a transformative, not disruptive, process to reform AEC education to satisfy industry needs and prepare students for future challenges. This requires a reimagined model of academia and industry collaboration in the new context, including organizational improvements, pedagogical improvements, and knowledge sharing.

a) Organizational improvements: A new model to sustain effective collaboration between academic programs and industry partners for timely communication of industry needs in multiple forms while considering constraints facing academic programs, recognizing differences in academic and industry goals, and reducing the mismatch between what the industry needs and what is taught in AEC programs.
b) Pedagogical improvements: AEC curricula to incorporate the education of emerging technologies that are in use in the industry, including but not limited to digital twinning, big data, and artificial

intelligence (AI), and inspiring teachers to teach and students to learn problems in real-world contexts, which are often complex.

c) Technology transfer: Lack of mechanisms to transfer novel technologies in university laboratories to industry practice.

d) Knowledge sharing and competency transfer: A new model that can help realize **IR 4.0** in the AEC industry and translate vanguard research on nascent technologies in academia such as digital fabrication, automation, AI & robotics, and sensing into industry practice.

e) Additional challenges (identified in the second workshop): Technology disruption, i.e., designing a procedure allowing the stakeholders to communicate about the limitations of the current technology in order to gradually design new technologies to replace the old one.

Actions and Priorities

The following is a list of actions proposed by participants of the two workshops, as well as the dot votes for each action by workshop two participants. Two groups of Workshop 2 participants provided complete mapping between challenges and actions. The top three important actions to the participants are Actions c, e, and a in descending order. From the mapping between actions and challenges, the number of actions that a challenge is mapped to in descending order is Challenge b and d (tie, four actions), Challenge a (three actions), and Challenge c (two actions). The results suggest that the actions mostly address pedagogical improvements and knowledge and competency transfer challenges. In the meantime, other challenges, especially those addressed by actions with a relatively high number of votes, should be considered, such as challenges a) and c). In addition, Challenge e, additional challenges, were identified in Workshop 2, but the participants did not provide matching actions for the challenge.

Actions	Final Large Group Dot Votes	Challenge Addressed
a) Identify specific gaps in the industry to realize IR4.0 or the implication of IR4.0 to the AEC industry and decide the role of AEC education. Address questions on how AEC education communities can bridge the gaps and refocus AEC education on transferable skills, enabling toolsets, and a growth mindset.	5	a, b, c, d
b) Sustain timely communication between academia and industry. Focusing on grand societal challenges such as climate change and adaptation is one of the approaches to	(merged with a)	

align practice on both sides to achieve a common goal. Explore different forms of collaboration, such as academic and industry alliances.		
c) Improve cross-training and foster skill sets needed to understand scientific methods, human behavior, material science, and ecology, in addition to computational thinking, communication skills, business savviness, and digital literacy.	9	b, d
d) Provide as much as possible the entire rich web of practice - explicitly or implicitly - so that students can use such information as needed. Treat design and engineering problems as wicked problems which need to be put into the proper context. To improve knowledge transferability, provide new methods to embed students' learning in appropriate real-world contexts.	1	a. b, d
e) Identify connecting concepts between disciplines to support deep integration of disciplinary knowledge and include those concepts in teaching.	7	a, b
f) Share lessons and experiences regarding scaling up the successful model from a single project and experiment/demonstration to sustainable and institutionalized models with continuous refinement.	0	N/A
g) Engage the technology industry	4	c, d
h) Engage accreditation agencies	0	N/A

INTERDISCIPLINARY EDUCATION

Multidisciplinary teamwork and communication are essential skills for AEC students to solve complex design and engineering problems in the future. Opportunities offered by emerging technologies have not been fully explored, such as new pedagogical strategies to deliver interdisciplinary learning content that is conducive to multiple disciplines.

Current Status

Interdisciplinary education for AEC students has long been recognized as a necessity. Many AEC programs (e.g., Stanford University, the University of Washington at Seattle, the University of Maryland at College Park, and the Ohio State University) have practiced multi/interdisciplinary courses with various delivery formats. However, a majority of today's AEC curriculum is siloed, which often hampers the true interdisciplinary programs focusing on disciplinary collaboration rather than cooperation. Additionally, such AEC programs mainly focus on in-depth knowledge development in their own discipline, with a secondary focus on balancing the need for interdisciplinary and disciplinary education. A few exceptions exist, such as the architectural engineering program at Penn State University, which integrates architectural engineering design and construction engineering into one curriculum.

Challenges

Bridge gaps within AEC curricula: Create synergy at the knowledge and organization levels among AEC disciplines, including foundational and transferable knowledge/skills related to learning new technologies and working across disciplinary lines. While universities and programs try to accommodate new ideas and developments in their courses and curricula, they often face challenges such as fragmented curricula, lack of expertise, and lack of standards.

a) Interdisciplinary education still faces curricular restrictions, logistic issues, organizational fragmentation, and varying student backgrounds. Each discipline has its program requirement dictated by the corresponding accreditation agency, which makes the likelihood very small to develop new courses where students from all three AEC disciplines can converge and benefit. Logistical issues such as scheduling, delivery mode, and credit hours are particularly challenging when students from three disciplines must be simultaneously in the same classroom. Teaching the same subject to students from different backgrounds and interests presents the biggest problem.
b) Deeper integration of AEC disciplines requires students to appreciate that data and information requirements, expertise, approaches to problems, and mindsets are different across disciplines. Recognizing such differences helps students understand how each discipline contributes to a common goal while lacking such appreciation often creates barriers to understanding shared

problems. In addition, the different mindsets and the approach to problems contribute to the difficulty in collaboration. Such causal relationships between disciplinary education and barriers to collaboration are not fully known. Questions, such as "what and how to overlap (knowledge, training, organization) among disciplines to facilitate collaboration?", "what would be a more systematic view regarding gaps among disciplines?" and "what are the strengths and limitations of project-based interdisciplinary models?" need to be answered.

c) Identifying other disciplines to be integrated into AEC education
d) Identifying the domains of opportunity areas of AEC education
e) Faculty mindset/willingness

Actions and Priorities

The top three actions are Actions d, f, and c. Most of those actions can be mapped to Challenges a) and b) (seven actions). Other challenges, such as c) (five actions) and d) (four actions), also received a high number of action mappings. The top three actions will address Actions a, b, c, and d. Although Challenge e was identified, the participants did not specify a matching action.

Actions	Final Large Group Dot Votes	Challenge Addressed
a) Informal education may offer new opportunities for interdisciplinary AEC education that traditional AEC education may not be able to handle, such as the solar decathlon competition.	0	a, b
b) Explore the method of using a common theme, such as robotics in AEC, to create interdisciplinary educational opportunities.	1	a, b, c, d
c) Explore a new model to balance between depth and breadth for curriculum design (professor's mindset, depth vs. breadth, problem-solving skills, multidisciplinary life-long learning skills, coding/programming, data/statistical capabilities, cognitive skills). Determine if a curriculum can be effectively designed and implemented as a reversed T with extension to other disciplines (breadth).	3	a, b, d
d) Foster an interdisciplinary collaboration mindset.	13	a, b, c, d

e) Promote inquiry-based processes to co-create knowledge and awareness of team dynamics, coaching, coordinating, and directing.	0	a, b, c
f) Investigate the role of emerging technologies in creating a better interdisciplinary learning environment, such as a cloud-based intelligent immersive platform (responsive environment, dynamic feedback, and experiential learning) and adaptive learning systems operated by AI algorithms for developing a learner profile (individual scaffolding and learning path for students of different disciplines).	8	a, b, c, d
g) Identify skills that AEC education must teach students to work across disciplinary lines.	1	a, b, c, e
h) Develop accreditation for interdisciplinary AEC	0	N/A

TECHNOLOGY AND LEARNING

Technology-mediated learning environments affect learning, including technology-generated artifacts such as 3D design models or construction site images. Fundamental questions need to be explored related to how emerging technologies, coupled with advancements in cognitive and education sciences, form disruptive forces to improve the learning environment.

Current Status

There are two distinctive topics in this theme. The first involves skills and knowledge related to technologies that the AEC industry applies, and the second is related to technologies that support teaching and learning. The impact of emerging technological advancements on the AEC industry is profound. For example, a recent article by Forbes noted that, in the foreseeable future, the industry would embrace new concepts, practices, and technologies, such as digital twins (DTs), artificial intelligence (AI), sustainability, resilient systems, big data, and the changing nature of engineering [11]. In addition, the 2021 Educause Horizon Report named AI, hybrid learning, learning analytics, micro-credentialing, open educational resources, and quality online learning as key technologies that would significantly impact future teaching and learning [5]. Such technological progress will transform AEC education in terms of content and delivery methods.

Challenges

Transform AEC education with emerging digital technologies: emerging digital technologies affect both the contents and the delivery methods of the next-generation learning-centered environment. They, however, present a series of challenges, including

a) Emerging technologies such as DTs, AI, cyber-physical systems (CPSs), and big data are transforming AEC industry practices. How do we take such initiatives by the industry and interpret them correctly for disciplinary and interdisciplinary AEC education?
b) The application of data-driven teaching/learning technologies such as AI in AEC education calls for new requirements in educational practice, for example, the need for developing new protocols and standards for handling data privacy and security.
c) The COVID-19 pandemic has accelerated the adoption of online learning. There is, however, a need to develop high-quality online/hybrid AEC education. Questions such as "what kind of in-person experience is missing in online delivery?", "what are the challenges and opportunities that hybrid delivery presents?" and "do we know enough to implement a successful online course and student learning in a virtual environment?" need to be explored.
d) How to teach collaboration

e) Accelerated learning
f) Accessibility
g) Feasibility of mobilizing actions
h) Deficit of fundamental knowledge of technology by students

Actions and Priorities

The results in the following table show that the top three actions are Actions e, a, and c in descending order. The results suggest that challenge a) is mostly addressed by actions (mapped to five actions). Challenges b), c), and f) (each mapped to three actions) are addressed. Other challenges are not specifically mapped to actions. The top three actions will address mainly Challenges a and b.

Actions	Final Large Group Dot Votes	Challenge Addressed
a) Have a better understanding of the role of emerging technologies such as AI and DTs and their potential in AEC education, including resolving conflicts among design, engineering, and construction and simulating in-person integrations. In the meantime, explore their implications on educational practices, such as data privacy and security.	6	a, b
b) Explore the idea of embedding digital technology education in a teaching environment where different learning modes (in-person and online), teaching platforms (digital and non-digital), and multidisciplinary teaching teamwork together to form an integrative teaching environment, such as the triple hybrid idea (i.e., hybrid learning environment, hybrid teaching platform, and hybrid teaching team).	0	a, b, c, f
c) Explore a new T–shaped education model across AEC disciplines and determine potential overlaps or connectivity among disciplines.	4	a
d) Improve the understanding of the relationship between indoor environmental quality (and occupant comfort) and learning	1	a, c, f

e) Consider the limitation of faculty knowledge, create pathways for faculty professional development, and provide effective incentives and rewards for faculty to incorporate new technologies into teaching or the curriculum.	15	a, b, c, f
f) Continue to develop new solutions to other identified challenges, such as different learning needs, varied student interests, and disciplinary backgrounds.	0	N/A

DIGITAL INEQUITY

The AEC education communities have widely embraced computer technologies in both in-person and online learning. Thus, it is important to understand the extent and influence of digital inequity while creating technology-intensive learning environments and to address the challenges by developing new pedagogical strategies.

Current Status

According to the National Digital Inclusion Alliance (NDIA), digital equity is "a condition in which all individuals and communities have the information technology capacity needed for full participation in our society, democracy, and economy"[4]. To date, the digital divide, educational inequality, and digital inequity remain significant societal problems in the US and around the world. Unfortunately, because the digital divide cannot be closed completely, it also affects social inequity. Identified factors contributing to digital inequality include cost, internet access, parent education, mobile devices, lack of information and/or digital literacy, socioeconomic status, race, and ethnicity. Current digital divide policies and discussions are mainly focused on student's physical access to digital technologies such as the internet. Nevertheless, it is clear that the digital divide and digital inequity are defined by physical access and other technology-related factors such as conditions of access, skills, uses, personal and social consequences of internet use, as well as personal factors such as disabilities and socioeconomic status. The issue of digital inequity and its impact on AEC students are significantly underexplored in AEC education.

Challenges

Create an inclusive learning environment: It should be recognized that students and faculty possess different levels of digital literacy, and students' social, economic, and disability statuses interact with their digital literacy and digital inequity. Fostering students' transferable skills in learning digital technologies to achieve equitable learning outcomes and developing a holistic view of digital inclusion are urgent. To this end, the following are among the key challenges that need further investigation:

a) Institutions of higher education face challenges in meeting the needs of students with varying levels of technological readiness. Deficiencies in digital literacy are shown to be a hindrance to their success. While both the contents and the learning environment can be digital technology-intensive, the challenge is how we use technology-enabled education to achieve equitable outcomes.

b) Digital adaptability is a relatively new concept in AEC education. It is largely unknown what constitutes digital adaptability for AEC students. It is important to explore how to foster such foundational skills and create a mindset committing to continuously developing such skills to

meet challenges due to evolving AEC education. In particular, how can we build digital adaptability among underserved AEC learners?

c) It is critical to develop a holistic focus on digital inclusion, which includes physical access to digital technologies and the entire teaching and learning ecosystem, such as considering the disabilities of students and the attitude toward such students. Subsequently, the challenge is systematically developing an understanding of digital inequity in AEC education.
d) Digital infrastructure
e) Involve K-12 and partnership

Actions and Priorities

The results show that the top three actions are Actions d, f, a, and e. Three groups reported meaningful mappings. Challenge b was addressed mostly by voted actions, followed by a tie between Challenges a and c, and then d. The top three actions address Challenges a, b, c, and d, but mostly a and b. The participants did not specify an action for Challenge e.

Actions	Dot Votes	Challenges Addressed
a) Explore concepts, theories, and methods for building AEC learners' digital inclusion, digital fluency, and digital adaptability.	2	a, b, c
b) In addition to developing digital literacy, media literacy, and information literacy skills, it is equally important to develop a growth mindset and self-directed learning habits to tackle challenges and opportunities presented in the digital age.	1	a, b
c) In AEC education, it is important to have continuous discourse about the evolving processes and technology norms in the industry. So, students can focus on building their confidence and attitudes and develop the core skills and understanding necessary to succeed.	0	N/A
d) Develop students' transferable skills and self-learning capability to deal with constant changes in technologies and mitigate the potential digital divide.	13	a, b

e) Create an inclusive community of practice and learning. Apply principles such as user-centered design (UCD) to change what we teach and how we teach, for example, the involvement of underserved students in ideation, assessment, and testing alternatives. Individualize teaching/learning delivery according to the conditions of each student.	2	c, d
f) Create pedagogically sound approaches to support lifelong learning, for example, supporting learners with micro-credentials and offering technology-enabled learning opportunities for such learners.	6	a, b, c
g) Develop holistic approaches to address digital inequity in education for students with disabilities, considering 1) access to hardware, software, and the internet, 2) accessibility of teaching and assessment tools, and 3) attitudinal barriers of faculty members.	1	b, c, d
h) Develop physical/digital infrastructure for inclusive and disability populations.	0	N/A
i) Develop bridges between K-12 / Higher Ed / Industry.	0	N/A

OUTCOMES

The qualitative results of the two workshops suggest that the next-generation learning-centered environment in AEC should be viewed as a technology-enabled, learner-focused, and evolving ecosystem. The components of the ecosystem are stakeholders, lifelong learning, technology, and contextual elements.

The concept of stakeholders refers to different types of organizations and individuals in the learning-centered environment, capturing who is involved in the environment. In the context of AEC education, they are academic institutions, accreditation organizations, the AEC industry, technology industries, professional societies, undergraduate AEC students, other students (graduate students and students in professional development programs), and faculty. Among them, the main focus is given to undergraduate AEC students and their teachers to support the mission of the NSF Improving Undergraduate STEM Education (IUSE) program. Considering the need to address lifelong learning, other types of students are also considered. Other stakeholders, such as industries and professional societies, play a role in this learning-centered environment, addressing undergraduate students' learning. Therefore, other students and stakeholders are included in the study wherever necessary.

There are many definitions of lifelong learning [12]. In this report, the concept refers to a process of students acquiring knowledge and skills, in particular transferable knowledge and skills such as problem-solving and critical thinking, in postsecondary AEC education. Although the main focus of this project is on the learning of undergraduate AEC students, lifelong learning means the knowledge and skills they learn can effectively support their training and learning needs in their professional and personal lives after graduation. This component captures what, how, and when to learn.

Technology refers to information and computer technologies (ICTs) broadly. They can be a learning subject or an enabling factor in the learning environment. This component only includes technology as an enabling factor. If technology is considered a learning subject, it is included in lifelong learning. This component captures the role or potential role of technology in supporting learning.

Contextual elements refer to identified situations explaining why a certain technology-enabled and learner-focused process should occur. The situational elements can be social (e.g., equity and accessibility including disability), technological (e.g., technology literacy), organizational (e.g., fragmentation and communication), economic (e.g., low-income and marginalized communities), industry practice (e.g., the

realization of Construction 4.0), or policy-related (e.g., tenure and promotion rules and guidelines). Many of those elements are constraints or restrictions to a learning process.

Vision Statements about the learning environment

AEC Curricula and Industry Practice

Inspires students in the AEC programs to learn emerging technologies, develop transferable skills such as cross-disciplinary skills and skills to learn emerging technologies, foster a growth mindset, and develop the ability to help the AEC industry to transform into Construction 4.0. The role of technology in supporting these learning activities needs to be explored. The learning activities need the support of 1) a new model of collaboration and communication to reduce the mismatch between what the industry needs and what is taught in AEC programs, 2) inspired and capable teachers, 3) relevant policies and guidelines at academic institutions to encourage curricula improvement, and 4) the involvement of accreditation organizations.

Interdisciplinary Learning

Creates a better integrated AEC curriculum model that fosters an interdisciplinary mindset and prepares students with balanced depths and breadth to be able to work across disciplinary lines. The role of technology in supporting these learning needs is to be explored. It is also essential that the faculty is inspired.

Technology and Learning

Enhances AEC learning environment using data-driven, AI, machine learning technologies, including emerging technologies for disciplinary and interdisciplinary education.

Digital inequity

Produces AEC students with digital fluency and digital adaptability and a growth mindset to cope with the evolving technological environment in the AEC industry and AEC education. AEC programs develop an understanding of digital inequity in AEC education systematically, not just physical access to digital technology but other factors such as considering disability and attitude toward such students.

Roadmap

The identified actions constitute major steps of the road map. The top three actions in each theme are:

AEC Curricula and Industry Practice

1. Improve cross-training and foster skill sets needed to understand scientific methods, human behavior, material science, and ecology, in addition to computational thinking, communication skills, business savviness, and digital literacy.
2. Identify connecting concepts between disciplines to support deep integration of disciplinary knowledge and include those concepts in teaching.
3. Sustain timely communication between academia and industry, focusing on grand societal challenges such as climate change and adaptation as an approach to align practice on both sides to achieve a common goal. Explore different forms of collaboration, such as academic and industry alliances. Specifically, identify specific gaps in the industry to realize IR4.0 or the implication of IR4.0 to the AEC industry and decide the role of AEC education. Address questions on how AEC education communities can bridge the gaps and refocus AEC education on transferable skills, enabling toolsets, and a growth mindset.
4. Engage the technology industry.

Interdisciplinary Education

1. Foster an interdisciplinary collaboration mindset.
2. Investigate the role of emerging technologies in creating a better interdisciplinary learning environment, such as a cloud-based intelligent immersive platform (responsive environment, dynamic feedback, and experiential learning) and adaptive learning systems operated by AI algorithms for developing a learner profile (individual scaffolding and learning path for students of different disciplines).
3. Explore a new model to balance between depth and breadth for curriculum design (professor's mindset, depth vs. breadth, problem-solving skills, multidisciplinary life-long learning skills, coding/programming, data/statistical capabilities, cognitive skills). Determine if a curriculum can be effectively designed and implemented as a reversed T with extension to other disciplines (breadth).

Technology and Learning

1. Consider the limitation of faculty knowledge, create pathways for faculty professional development, and provide effective incentives and rewards for faculty to incorporate new technologies into teaching or the curriculum.
2. Have a better understanding of the role of emerging technologies such as AI and DTs and their potential in AEC education, including resolving conflicts among the design, engineering, and

construction disciplines and simulating in-person integrations. In the meantime, explore their implications on educational practices, such as data privacy and security.

3. Explore a new T–shaped education model across AEC disciplines and determine potential overlaps or connectivity among disciplines.

Digital Equity

1. Develop students' transferable skills and self-learning capability to deal with constant changes in technologies and mitigate the potential digital divide.
2. Create pedagogically sound approaches to support lifelong learning, for example, supporting learners with micro-credentials and offering technology-enabled learning opportunities for such learners.
3. Create an inclusive community of practice and learning. Apply principles such as user-centered design (UCD) to change what we teach and how we teach, for example, the involvement of underserved students in ideation, assessment, and testing alternatives. Individualize teaching/learning delivery according to the conditions of each student.
4. Explore concepts, theories, and methods for building AEC learners' digital inclusion, digital fluency, and digital adaptability

To support the AEC community in implementing the actions toward the vision, the participants proposed the following immediate tasks:

1. Create a virtual group using social media such as Slack Channel to keep the momentum
2. Create a presence and share outcomes
    a. Consider creating Newsletters
    b. Organize tracks in events such as ASCE, AIA, and ACEE conferences
    c. Organize special collections
3. Disseminate and share research findings and practices with the larger community through conferences organized by ASEE and ASCE
4. Involve industries with industry-lead events
5. Involve professional societies
6. Involve Ph.D. students and organize student activities
7. Involve minority-serving institutions
8. Create an organization
    a. Organize task forces
    b. Explore funding opportunities

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APPENDIX I: WORKSHOP 1 PROGRAM

Day 1:

Time (Central)	Topic	Note
11:00 AM – 11:10 AM	Welcome & Introduction	Dr. Yimin Zhu, Louisiana State University
11:10 AM – 11:50 AM	Keynote Speech	Dr. Alexandra Medina-Borja, Program Director, National Science Foundation
11:50 AM – 1:00 PM	Presentations	Digital Inequity Theme Moderator: • Dr. Amir H. Behzadan, Texas A&M University Speakers: • Dr. Nicole Buzzetto-Hollywood, University of Maryland • Dr. Lin Lin, University of North Texas • Dr. Yvette E. Pearson, The University of Texas at Dallas
1:00 PM – 1:30 PM	Panel Discussion	Q&A in Digital Inequity Theme
1:30 PM – 2:00 PM	Break	
2:00 PM – 3:10 PM	Presentations	Interdisciplinary Education Theme Moderator: • Dr. Yimin Zhu, Louisiana State University Speakers: • Dr. Shahin Vassigh, Florida International University • Dr. Carrie Sturts Dossick, University of Washington • Dr. Yong Tao, Cleveland State University
3:10 PM – 3:40 PM	Panel Discussion	Q&A in Interdisciplinary Education Them
3:40 PM – 4:00 PM	Summary & Adjourn	Dr. Sheryl Sorby, University of Cincinnati

Day 2:

Time (Central)	Topic	Note
11:00 AM – 11:05 AM	Welcome & Introduction	Dr. Yimin Zhu, Louisiana State University
11:05 AM – 12:00 PM	Industry Panel	Moderator: • Dr. Renate Fruchter, Stanford University Panelists: • Josh Rounds, Performance Contractors, Inc. • David Helveston, Associated Builder & Contractor's Pelican Chapter • Heath May, HKS LINE (Laboratory for INtensive Exploration) • Wayne Berlin, Worley
12:00 PM – 1:10 PM	Presentations	Technology and Learning Theme Moderator: • Dr. Raymond Issa, University of Florida Speakers: • Dr. Ming Hu, University of Maryland • Dr. Aliye Karabulut-Ilgu, Iowa State university • Dr. Carol C. Menassa, University of Michigan
1:10 PM – 1:40 PM	Panel Discussion	Q&A in Technology and Learning Theme
1:40 PM – 2:00 PM	Break	
2:00 PM – 3:10 PM	Presentations	AEC Curricula and Industry Practice Theme Moderator: • Dr. Amirhosein Jafari, Louisiana State University Speakers: • Dr. Shane Brown, Oregon State University • Dr. Yong Bai, Marquette University

Day 3:

Time	Topic	Note
11:00 AM – 11:15 AM	Introduction	Dr. Yimin Zhu, Louisiana State University
11:15 AM – 12:00 PM	Breakout Session 1	
12:00 PM – 12:45 PM	Breakout Session 2	
12:45 PM – 1:15 PM	Break	
1:15 PM – 2:00 PM	Breakout Session 3	
2:00 PM – 2:45 PM	Breakout Session 4	
2:45 PM – 3:15 PM	Break	
3:15 PM – 3:45 PM	Discussion Summary	
3:45 PM – 4:00 PM	Adjourn	Dr. Yimin Zhu, Louisiana State University

1

“Next Generation Learning-Centered Environment for Architecture, Engineering, and Construction (AEC) Education.”

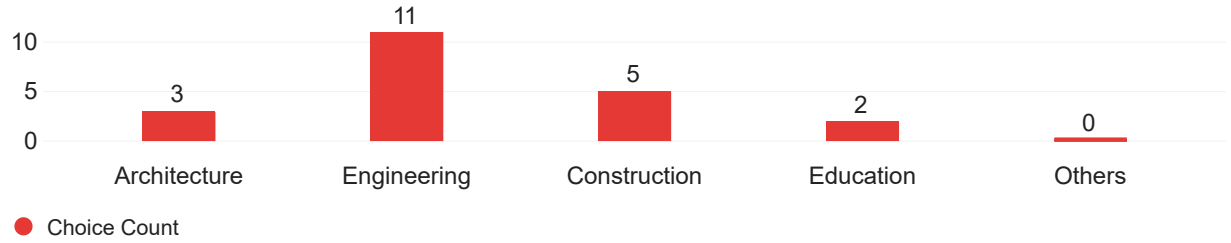
Study Number: 2131887
Name of Funding Agency: National Science Foundation Principal
Investigator: Dr. Yimin Zhu (yiminzhu@lsu.edu)

The goal of this survey was to provide a framework for the architecture, engineering, and construction (AEC) community to create a shared vision of the next generation learning-centered environment for AEC education. While constantly seeking more effective solutions to traditional challenges, such as collaboration with industry partners for curriculum enhancement and the integration of AEC curricula, the AEC education community is facing new challenges such as the impact of emerging technologies on its curricula, the learning environment, and digital equity. To prepare a future-ready AEC workforce, the AEC community needs to address these traditional and new challenges effectively.

The survey focused on the needs of the stakeholders (i.e., students, faculty, AEC programs, and AEC industries), the challenges facing the AEC education community, and solutions. Accordingly, the following discussions are structured in four themes:
1) AEC Curricula and Industry Practice,
2) Technology and Learning,
3) Interdisciplinary Education, and
4) Digital Inequity.

Project Investigators:
Dr. Yimin Zhu (yiminzhu@lsu.edu) from Louisiana State University
Dr. Amir H. Behzadan (abehzadan@tamu.edu) from Texas A&M University
Dr. Amirhosein Jafari (ajafari1@lsu.edu) from Louisiana State University Advisory
Dr. R. Raymond Issa (raymond-issa@ufl.edu) from the University of Florida

Participants field of expertise:

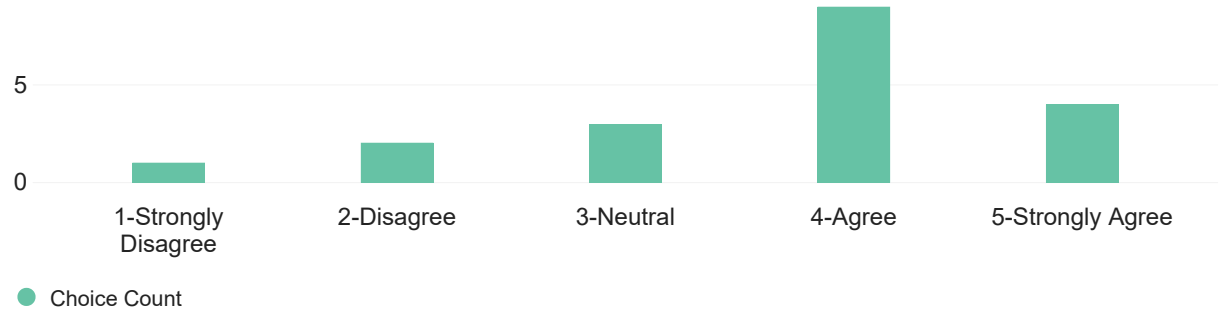


Theme 1: AEC Curricula and Industry Practice

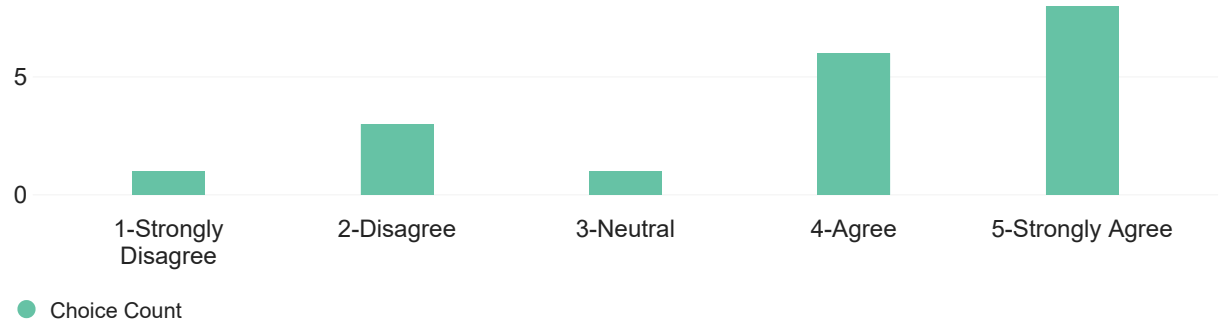
Background: There is a need to create a transformative, not disruptive, process to reform AEC education to satisfy industry needs and prepare students for future challenges. This requires a reimagined model of academia and industry collaboration in the new context, including organizational improvements, pedagogical improvements, and knowledge transfer.

Specific challenges are:

1) How industry needs are timely communicated with AEC programs while considering constraints facing the programs and reducing the mismatch between what the industry needs and what is taught in AEC programs.



2) How AEC curricula effectively incorporate the education of emerging technologies that are in use in the industry, such as digital twinning, big data, and AI.



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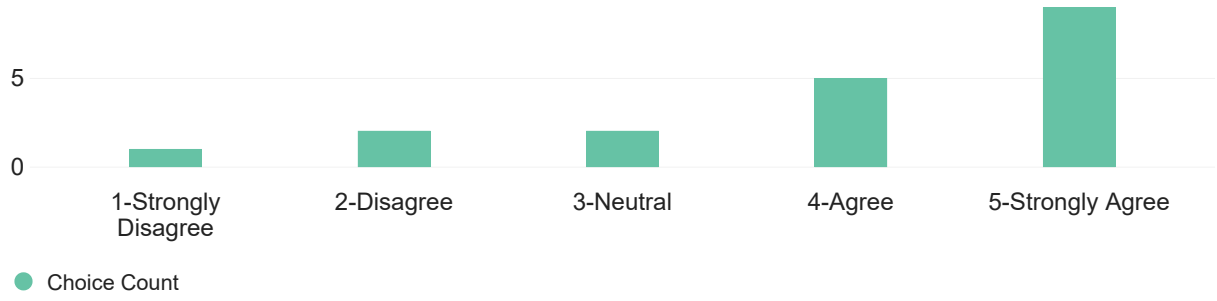
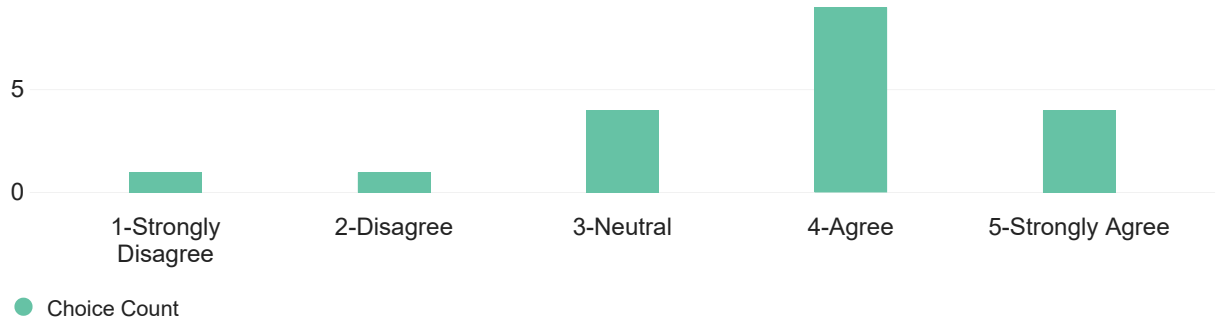
3) How AEC programs improve knowledge transferability by inspiring teachers to teach and students to learn problems in real-world contexts, which are often complex and challenging.



4) How AEC program can best support the AEC industry to realize Industry Revolution 4.0 (IR 4.0).



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5) Please list other relevant challenges or comments:

How the instructors/faculties are ready to teach these concepts and have the required teaching skills, work experience, and familiarity with technologies?

The notion of addressing digital inequality or difference as mentioned in the report is also a critical aspect. Part of this is not just exposure to technology, but developing shared understandings, mental models, sociocultural practices, recognizing affordances, etc.

How AEC programs increase students' awareness of the range of career options available and how to pursue those options.

Most AEC programs are mired in what has been historically taught.

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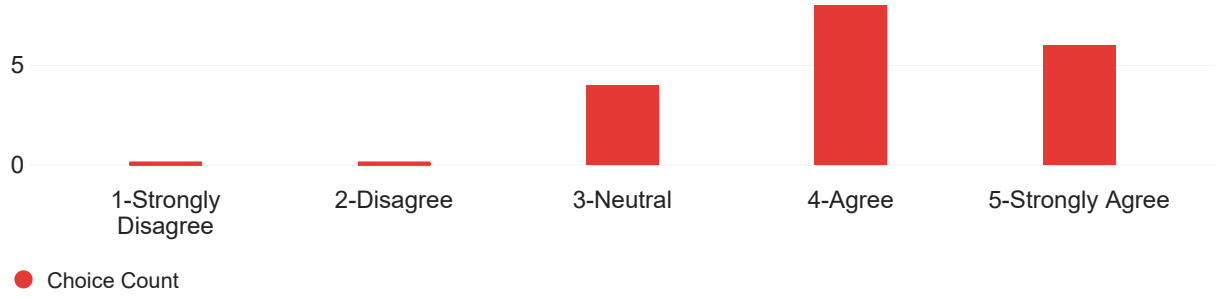
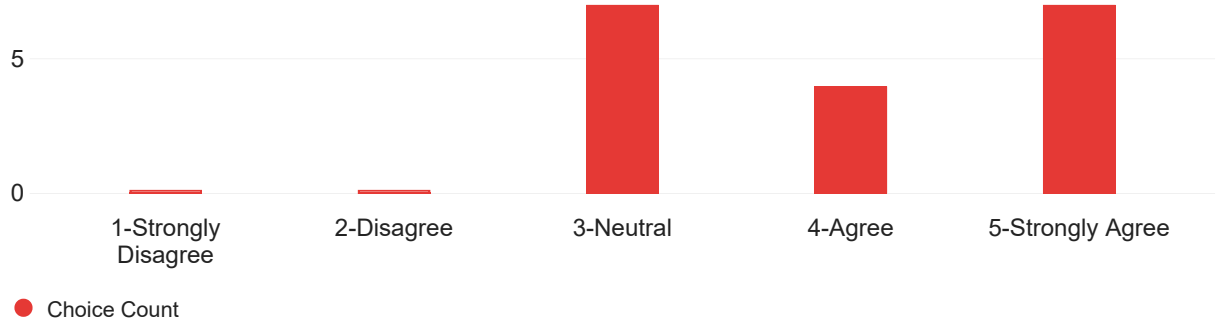
9) Share lessons and experiences regarding scaling up successful education models, from a single project and experiment/demonstration to sustainable and institutionalized models with continuous refinement.



10) Translate vanguard research on nascent technologies in academia such as digital fabrication, automation, AI/ML, robotics, and sensing into industry practice.



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Bridge the gap by co-teaching the courses (faculty and industry partner)

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While I agree there is an issue of some mismatch between what students learn and what students need for professional practice, I would also raise a little caution that the goals of education and industry, even for fields like AEC are not a one-to-one translation. The pressures and goals of both systems (academia and industry) inherently are different in some regards and this is always going to create some difference of perspective. I think insight from both groups is necessary, but needs to be carefully synthesized, taking into consideration holistically educational goals and supporting critical, reflective thinkers, and also preparing students to be responsive to the realities of industry settings. Sometimes this point can push a little too far into the notion of simply providing training for industry practice, but with industry always moving, even if this were possible (it usually isn't given the constraints within academia) we would never arrive at that one-on-one mapping. So, instead I encourage a thoughtful synthesis.

Identify methods to help students access information about AEC industries and the knowledge and skills necessary to succeed in those industries.

Identify methods for students to learn more about professional communities associated with the sub-challenges associated with Engineering Grand Challenges.

I think most of these are too ambitious for a single workshop to accomplish

Improve widespread acceptance and buy-in of comprehensive student digital literacy improvement across educators and administrators.

Again, upskilling and reskilling of AEC faculty (i.e., professional development) is critical to the learning outcomes of AEC graduates.

Use existing learning models such as student team competitions. Industry members develop real-world scenarios, and students are responsible for responding to them and getting instant feedback about their solutions.

Meeting ABET outcomes is top priority for AE program.
Functional narrative around building systems integration and implications on achieving aggressive targets I.e. Arch2030.

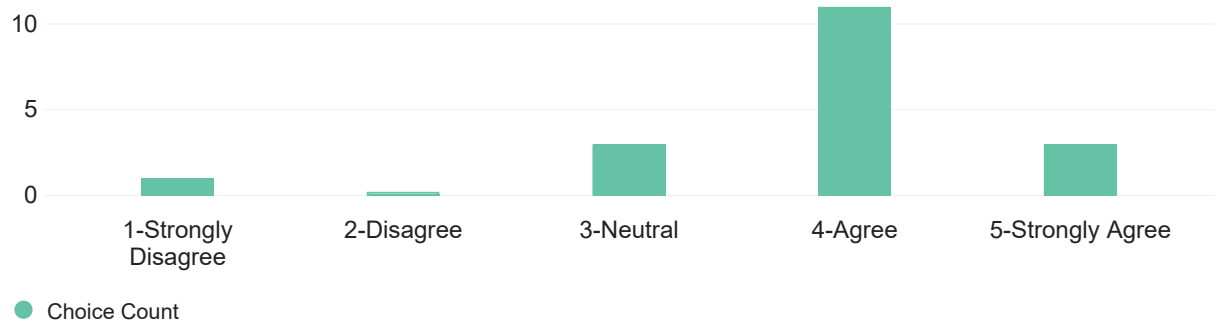
9

Theme 2: Technology and Learning

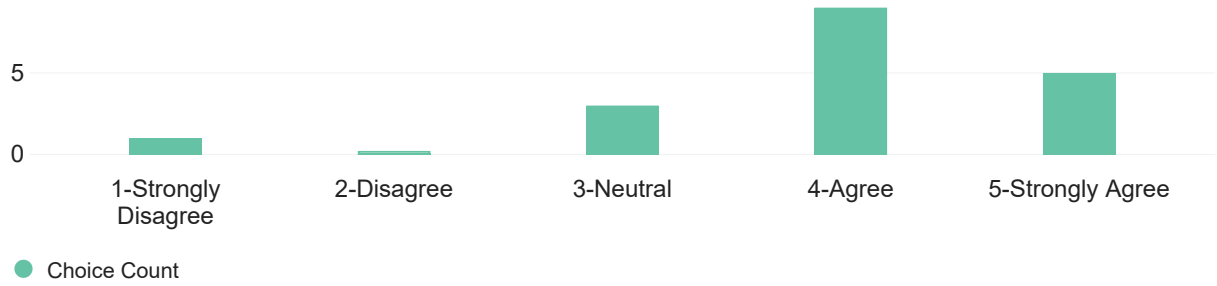
Background: Emerging digital technologies such as digital twins (DTs), artificial intelligence (AI), cyber-physical systems (CPSs), and big data are transforming AEC industry practices. In the meantime, such technologies also affect both the contents and the delivery methods of the next generation learning-centered environment. One impact on AEC education is the adoption of online learning, which has been accelerated by the COVID-19 pandemic.

Specific challenges are:

1) How AEC programs can correctly interpret the initiatives of the AEC industry to adopt emerging digital technologies and subsequently enhance disciplinary and interdisciplinary AEC education.



2) What new requirements, protocols, and standards in AEC educational practice are needed to apply data-driven teaching/learning technologies such as AI in AEC education calls for new requirements in educational practice while protecting data privacy and security of students.



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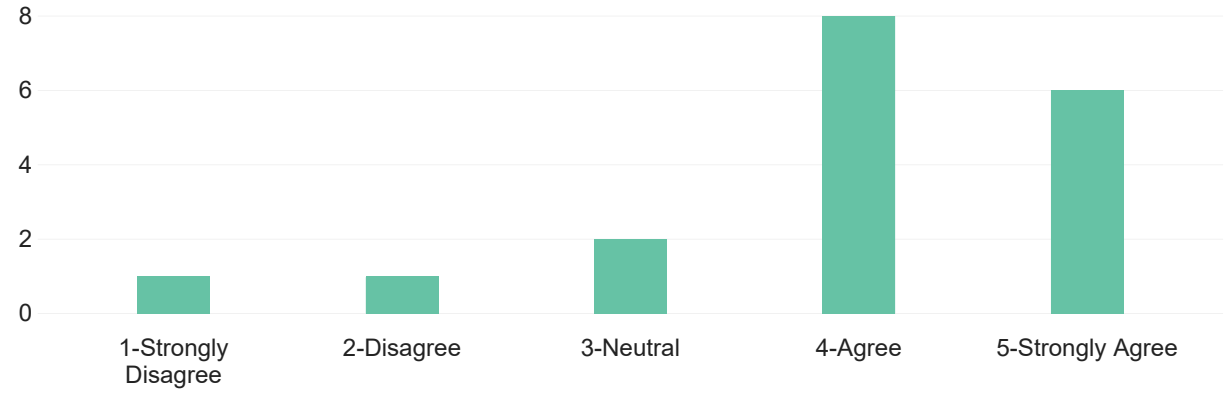
3) How AEC programs develop high-quality online/hybrid AEC education.



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We can also think about how industry 4.0 technologies can be used to enhance education, such as using IoT and AI systems within various digital and hybrid learning environments and leveraging developments in learning analytics, AI applied education research, game-based learning, etc.

How AEC programs identify core knowledge and skills that prepare students to adapt and use new technologies emerging in industry.

How to maintain and increase student engagement through new hybrid and online learning paradigms.

Paralleling online instruction with online instructions due to Covid is an oversimplification.

Flexibility, adaptability and agility for academia and industry to react, respond to and become resilient to deal with real-world issues including pandemic, energy, extreme weather, inflation, etc.

Specific actions are to:

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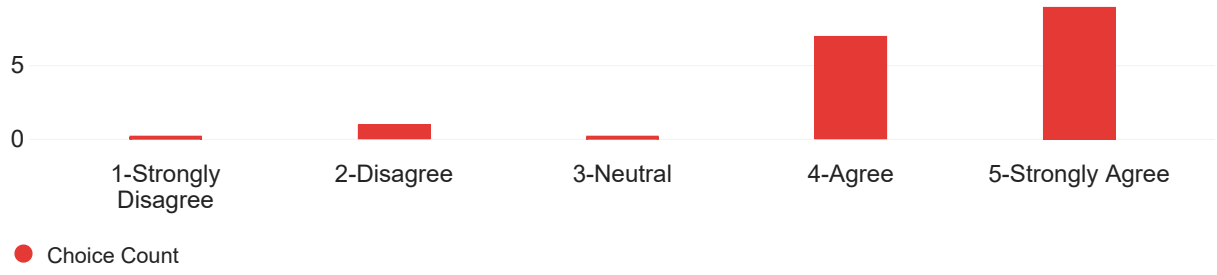
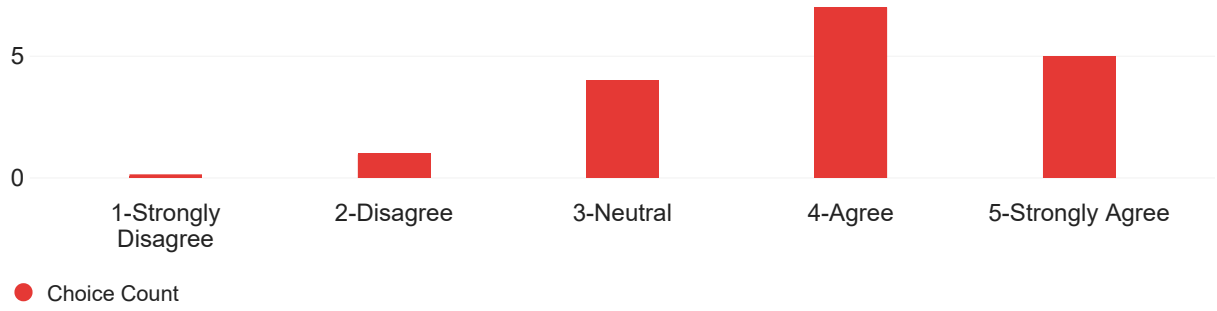
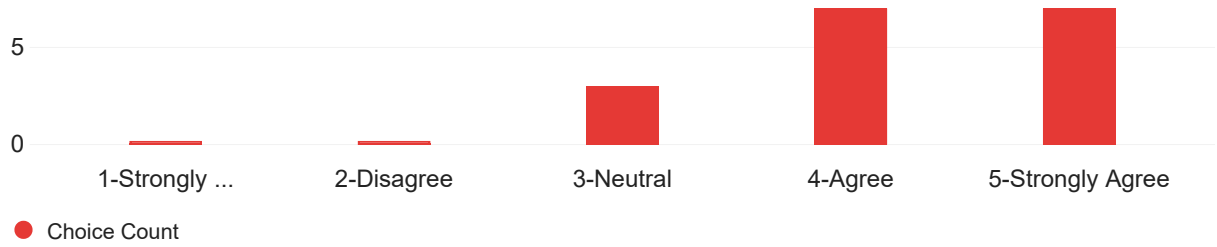
1) Develop a better understanding of the role of emerging digital technologies and their potential in AEC education, including resolving conflicts among design, engineering, and construction and simulating in-person integrations.



2) Explore the implications of emerging digital technologies on educational practices, such as data privacy and security.



3) Explore the idea of embedding digital technology education in a teaching environment where different learning modes (in-person and online), teaching platforms (digital and non-digital), and a multidisciplinary teaching team work together to form an integrative teaching environment.



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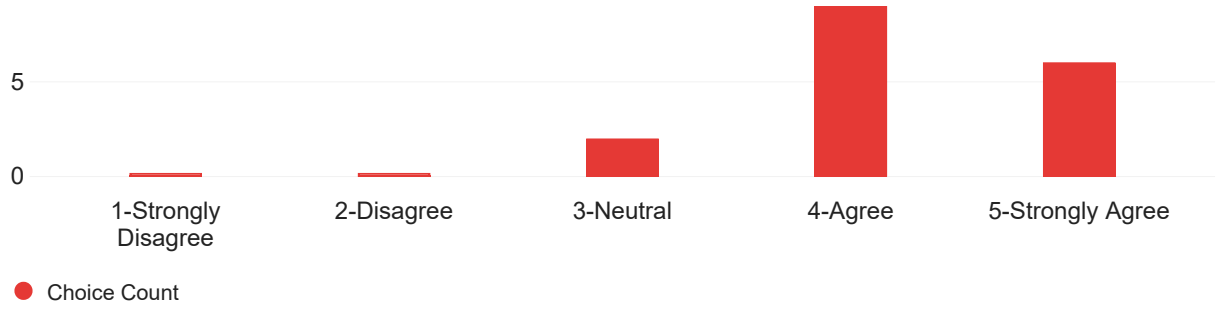
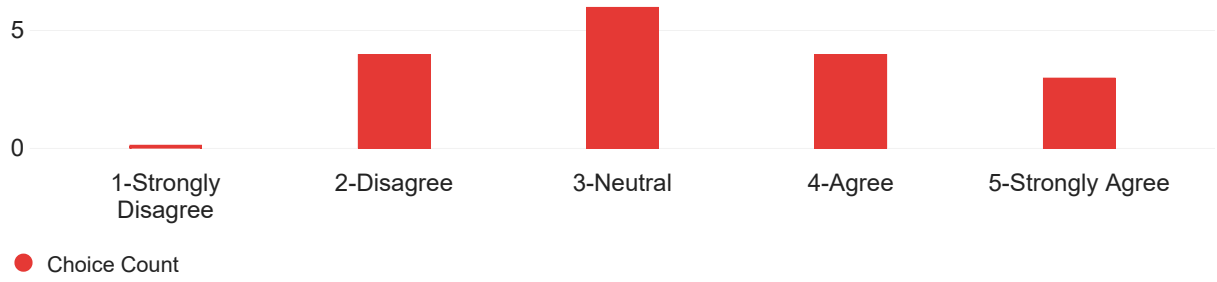
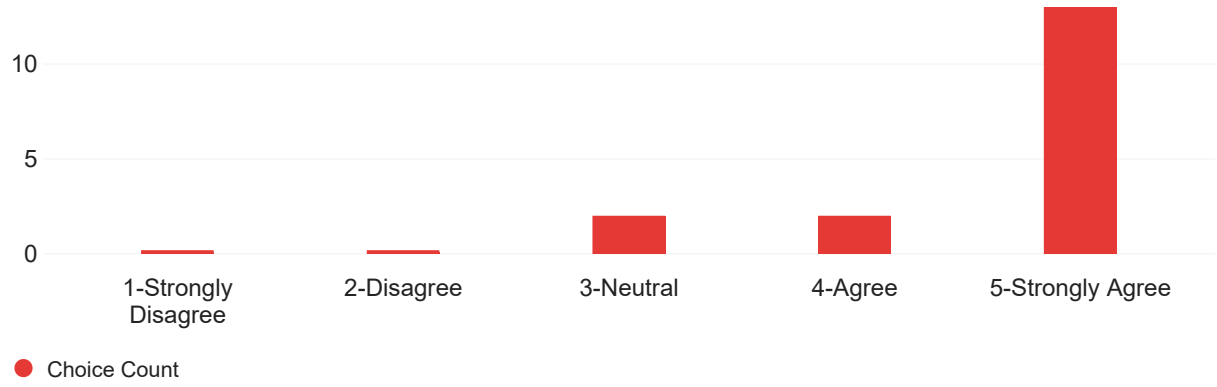
4) Explore a new T–shaped education model across AEC disciplines and determine potential overlaps or connectivity among disciplines.



5) Develop a better understanding of the relationship between indoor environmental quality (and occupant comfort) and learning.



6) Create pathways for faculty professional development, and provide effective incentives and rewards for faculty to incorporate new technologies into teaching or the curriculum.



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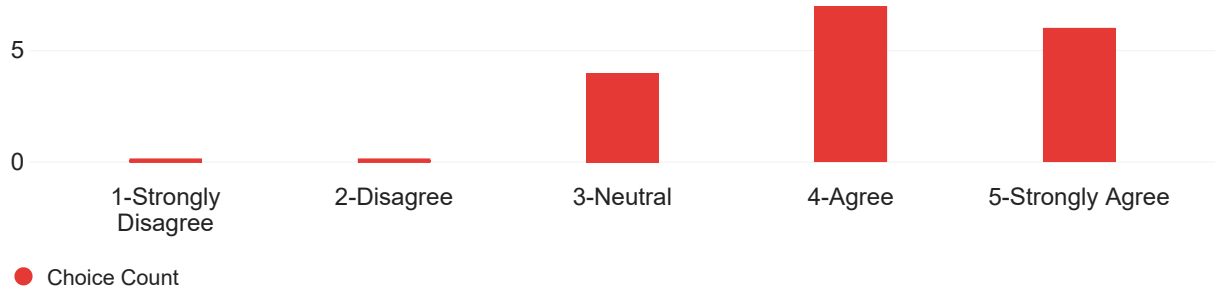
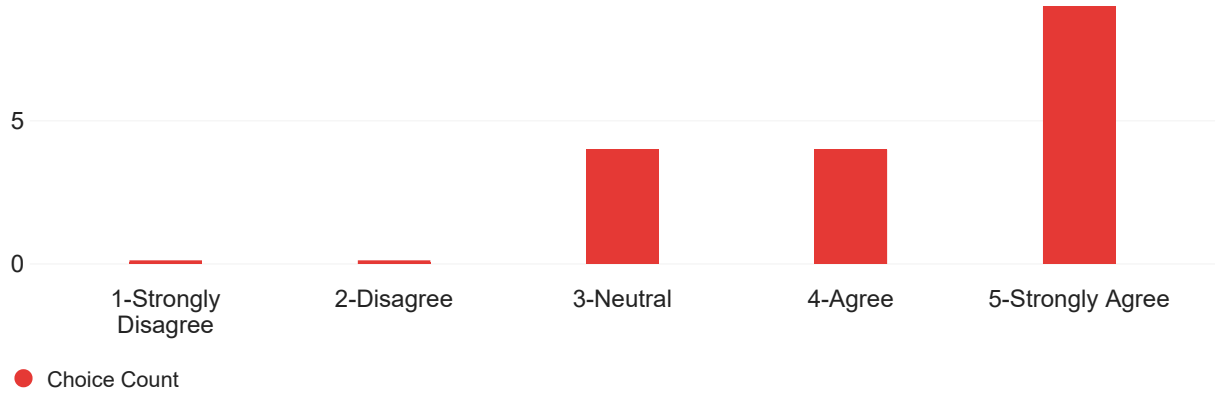
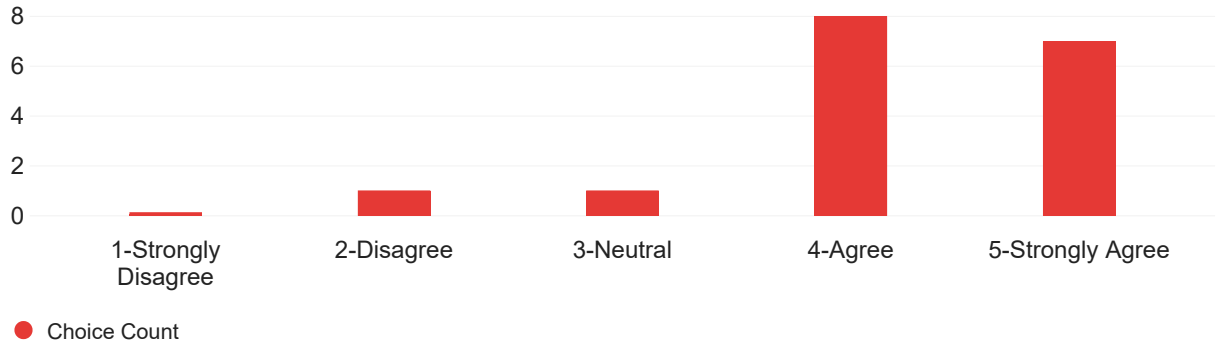
7) Develop new solutions to other identified challenges, such as different learning needs, varied student interests, and disciplinary backgrounds.



8) Explore whether any type of in-person experience is missing in online delivery and the impact on learning.



9) Develop a better understanding on the challenges and opportunities that hybrid delivery presents.



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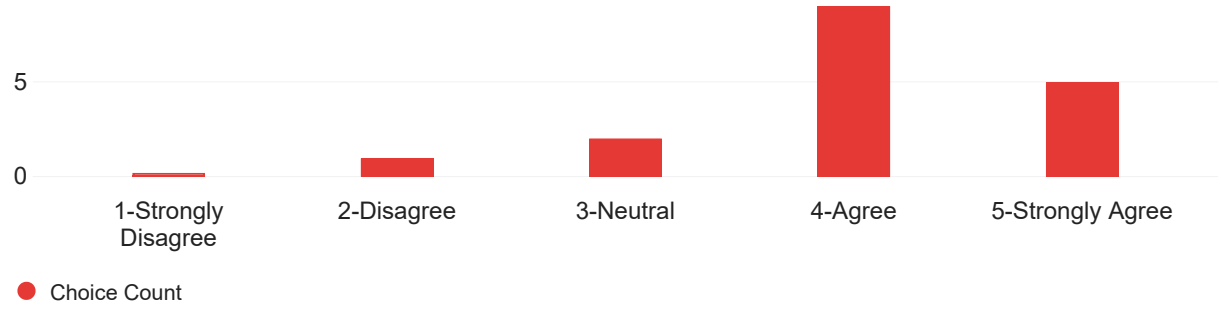
10) Develop a better understanding of implementing a successful online course and supporting student learning online.



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Improved understanding of the operational support infrastructure needed for creating successful online learning expereinces.

Support more holistic teaching workshops for faculty during semesters and summer breaks.

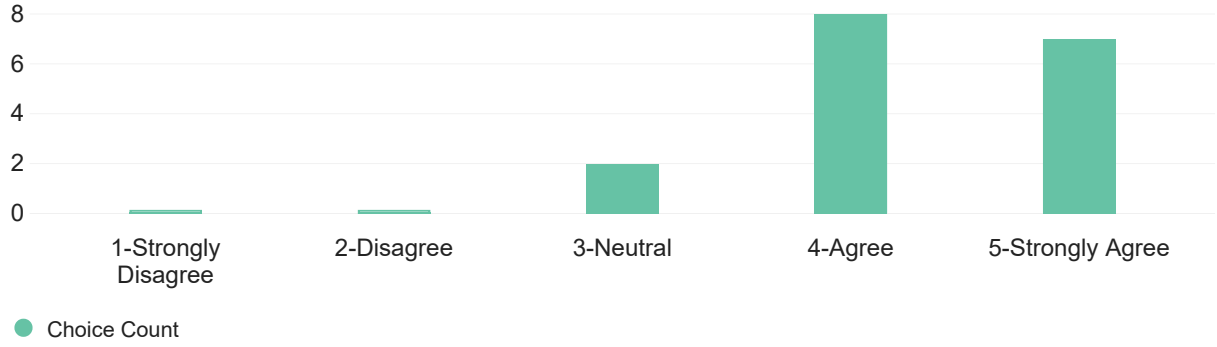
Dissect the modalities most appropriate for varied learners and type of classroom delivery I.e. lecture vs studio.

Theme 3: AEC Interdisciplinary Education

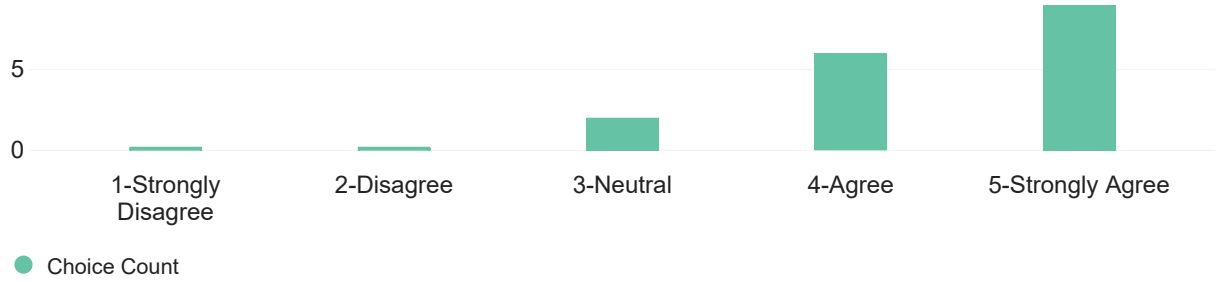
Background: Interdisciplinary education still faces curricular restrictions, logistic issues, organizational fragmentation, and varying student backgrounds. While universities and programs try to accommodate new ideas and developments in their courses and curricula, they often face challenges such as fragmented curricula, lack of expertise, and lack of standards. In addition, each discipline has its program requirement dictated by the corresponding accreditation agency, which makes the likelihood very small to develop new courses where students from all three majors can converge and benefit.

Specific challenges are:

1) How AEC programs create synergy at the knowledge and organization levels among AEC disciplines.



QC3.2 - 2) What foundational and transferable knowledge/skills are needed for AEC students to learn new technologies and work across disciplinary lines.



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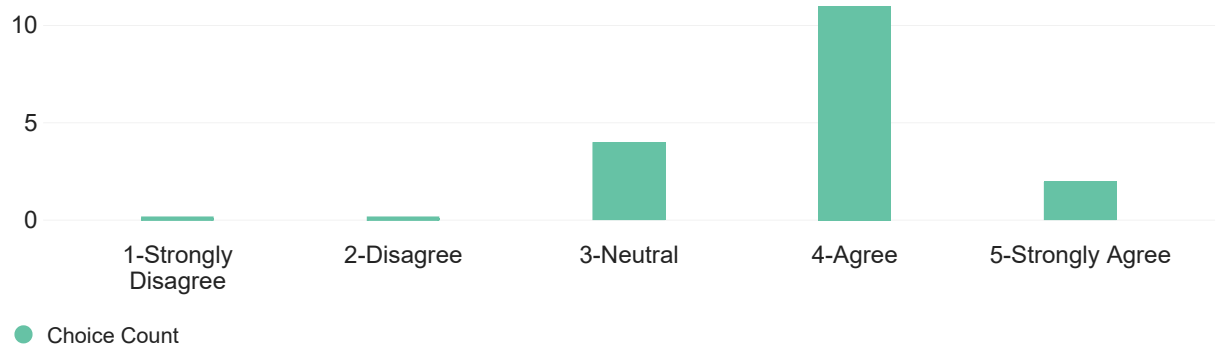
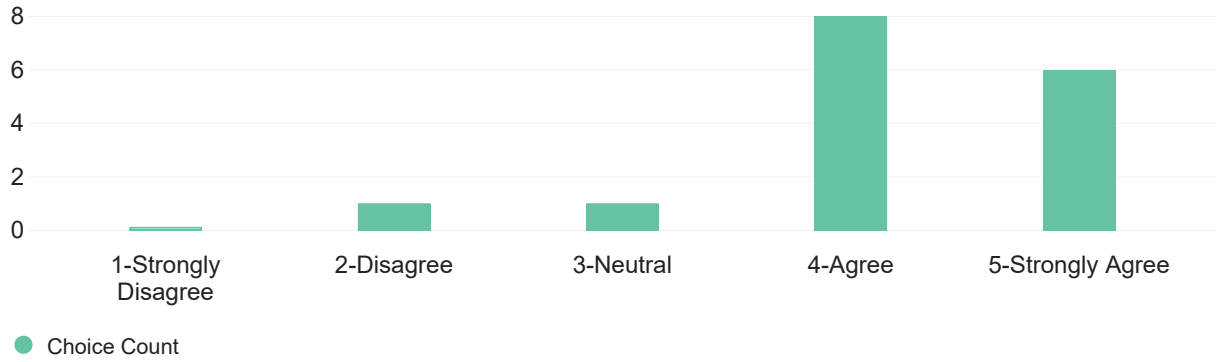
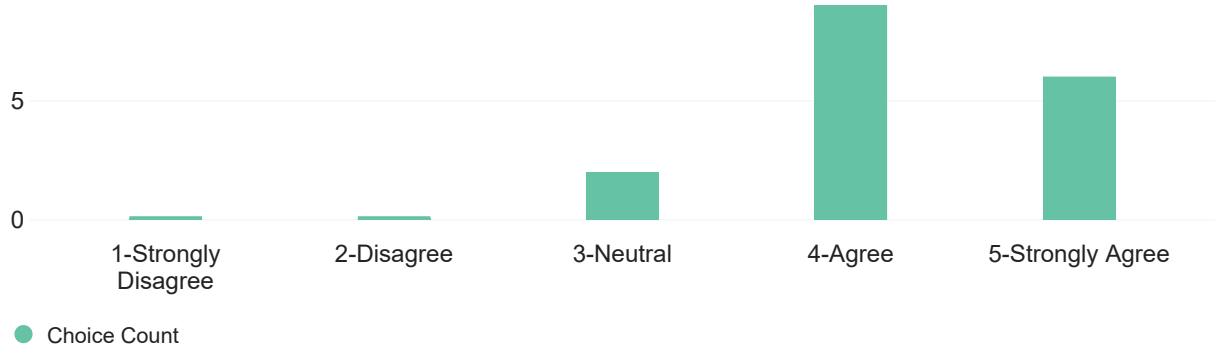
3) What causal relationships between disciplinary education and barriers to collaboration are.



4) How AEC programs create a systematic view regarding gaps among disciplines.



5) How AEC programs overlap (knowledge, training, organization) among disciplines to facilitate collaboration



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6) Please list other relevant challenges or comments:

6) Please list other relevant challenges or comments:

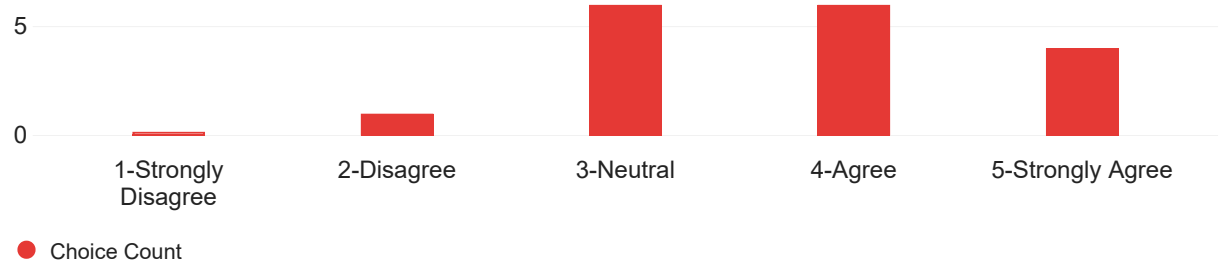
None.

Development of individual's drive and learn the basis of partnering disciplines for collaboration aremore important than developing technology and tools.

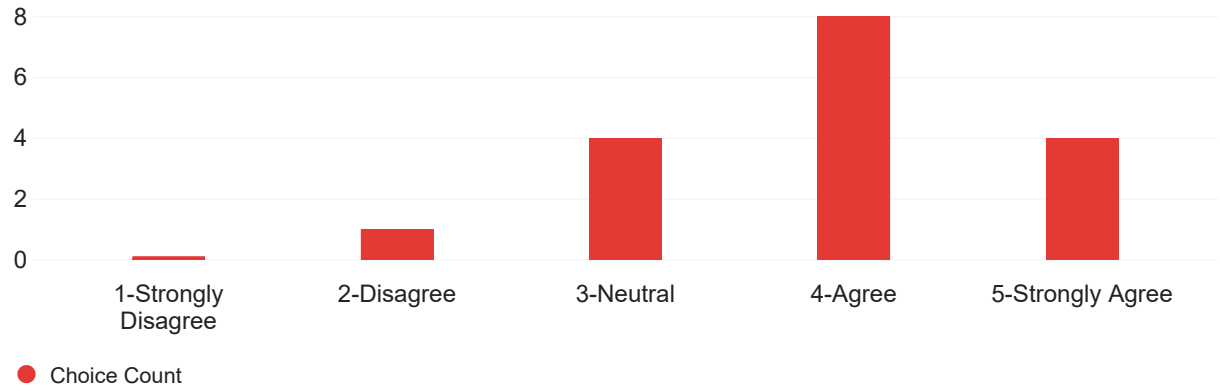
Much needed disciplinary engagement is challenging and limited by silos and inadequate resources and lack of support and encouragement from academic administration focused internally.

Specific actions are to:

1) Implement informal education to offer new opportunities for interdisciplinary AEC education that traditional AEC education may not be able to handle, e.g., the solar decathlon competition.



2) Explore the method of using a common theme such as robotics in AEC to create interdisciplinary educational opportunities.



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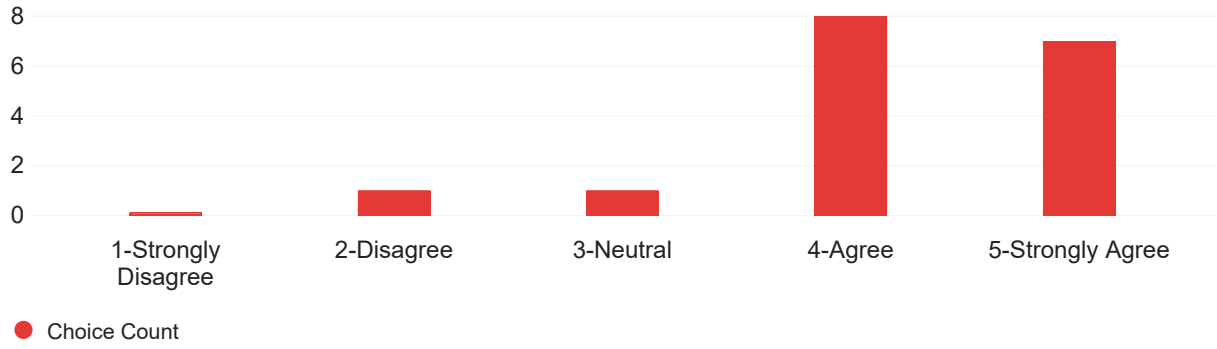
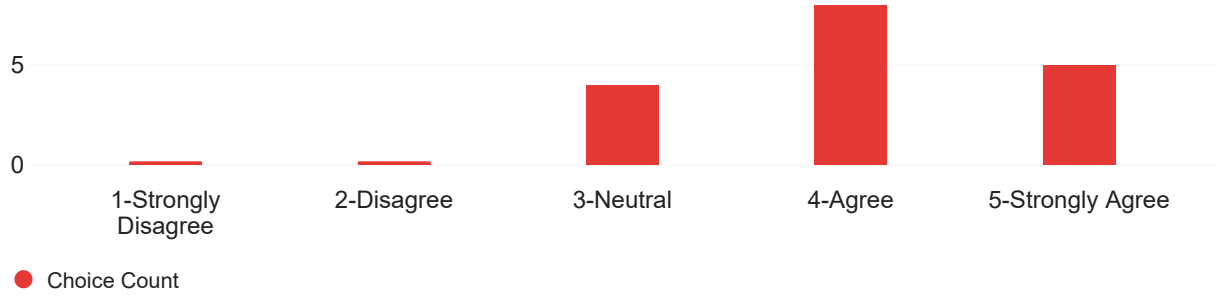
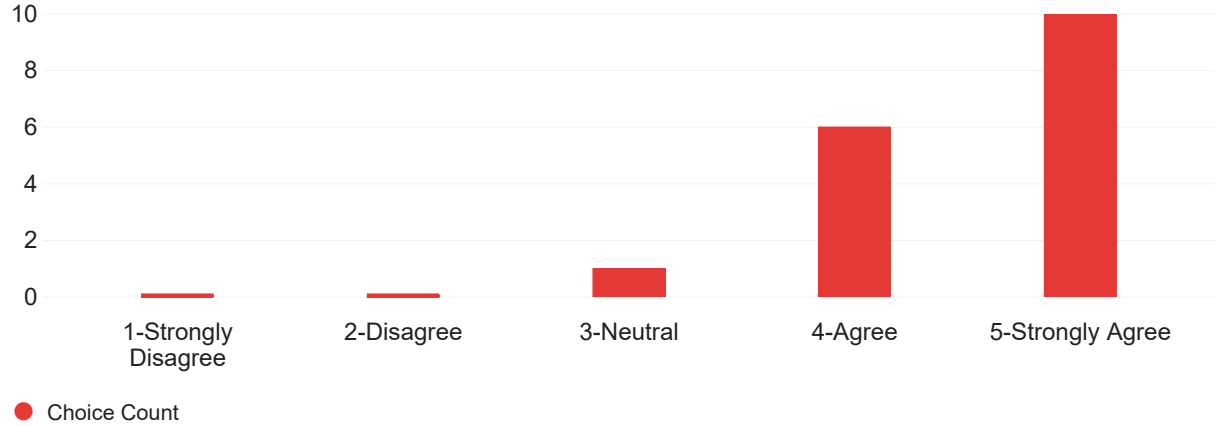
3) Explore a new model to balance depth and breadth for curriculum design.



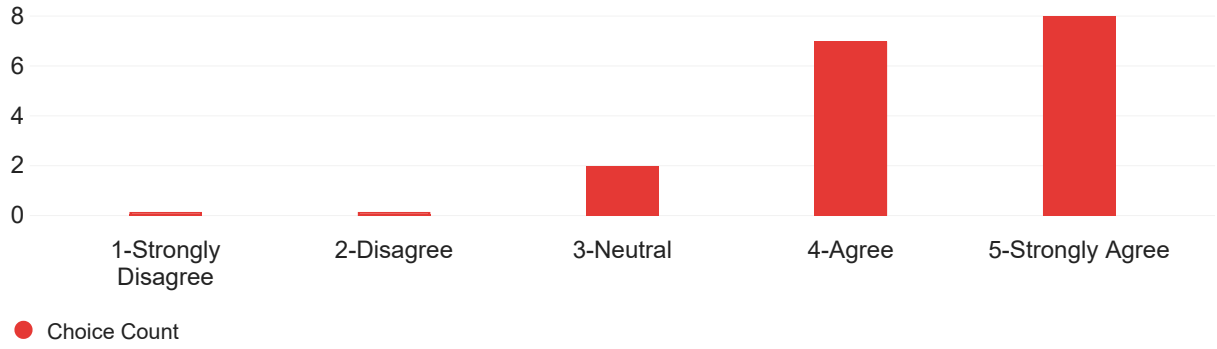
4) Determine whether a curriculum can be effectively designed and implemented as a reversed T with extension to other disciplines (breadth).



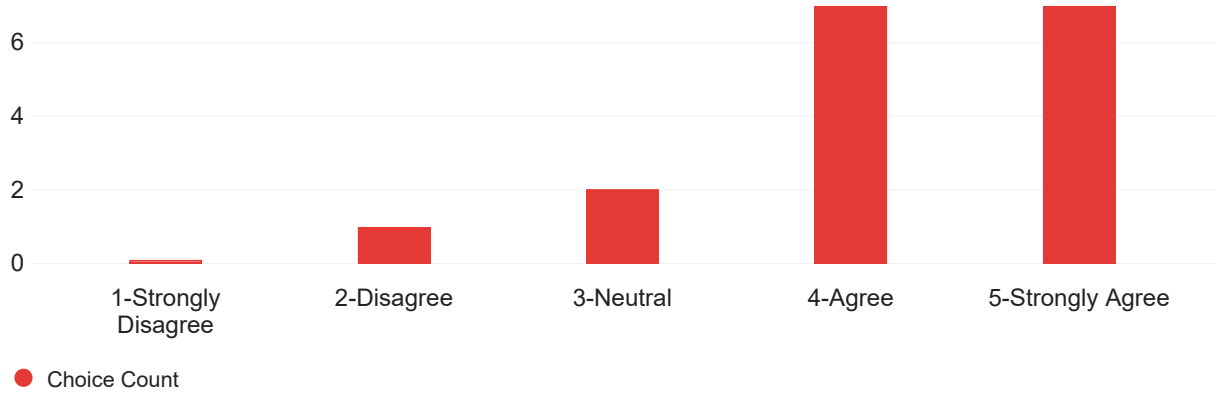
5) Foster an interdisciplinary collaboration mindset.



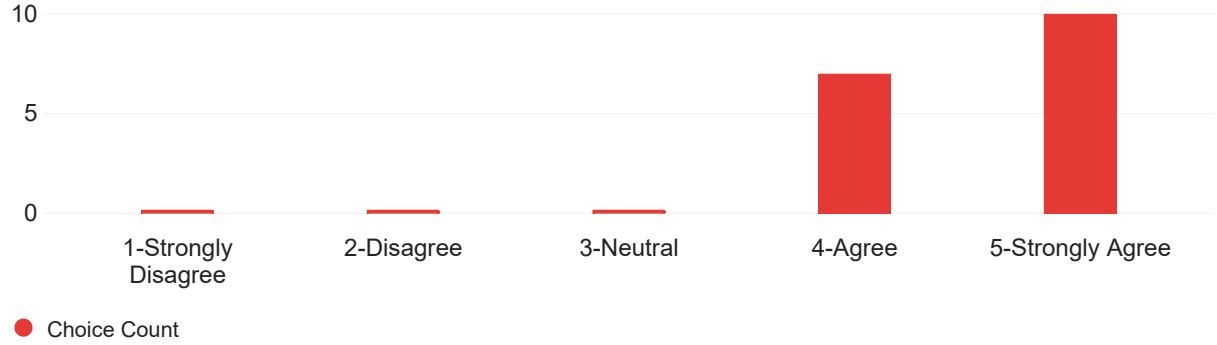
6) Promote inquiry-based processes to co-create knowledge and the awareness of team dynamics, coaching, coordinating, and directing.



7) Investigate the role of emerging technologies in creating a better interdisciplinary learning environment.



8) Identify skills that AEC education must teach students to work across disciplinary lines.



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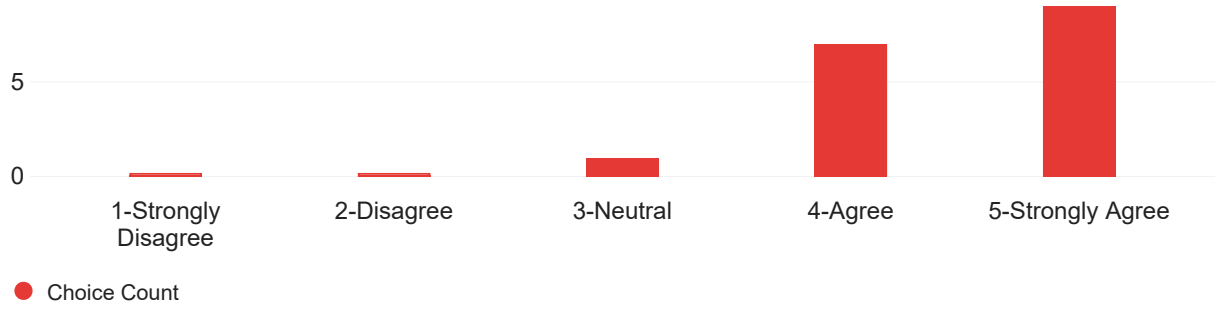
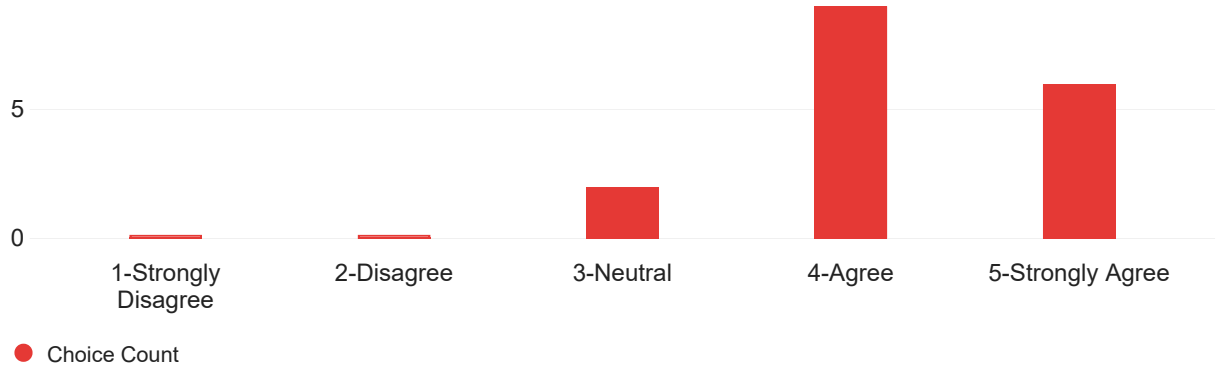
9) Help students understand how each discipline contributes to a common goal.



10) Help students appreciate that data and information requirements, expertise, approaches to problems, and mindsets are different across disciplines.



11) Please list other relevant actions or comments

11) Please list other relevant actions or comments

For common themes across AEC, I would just suggest being careful with how these are chosen as not all may have the same appeal across different groups of students within our fields.

Number 10's use of "appreciate" is ambiguous. I think this relates to developing/applying the skills described in the previous sections. This section focuses on developing students ability to seek multiple factors associated with solving an problem which includes knowing the roles associated with other disciplines and their importance in multidisciplinary projects. These skills are necessary for leading a large project with a large team of expertise. Being familiar with their skill set and Roles will be critical to the success of the project.

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Cultivate AEC industry champions to educate instructors and students on the imperative need to advance emergent technological competency and skill in advanced education enviornments.

Use appropriate and applicable assessment techniques that authenticate students overall mastery of the related concepts

Must find space in the AEC education to introduce some depth in breath topics education at the same time develop the expertise in the depth topics. Give students the knowledge base to execute integrative work.

Help students understand how each discipline contributes to a common goal and multiple diverse goals.

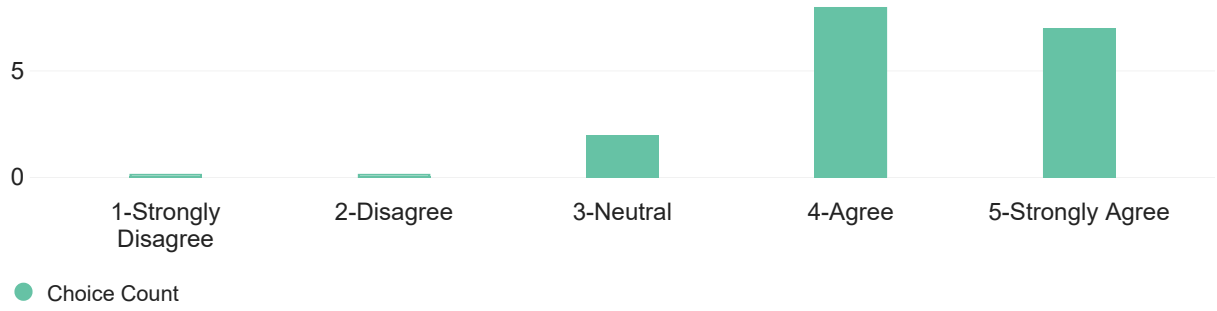
Encourage multidisciplinary capstone project teams and celebrate inclusive pedagogy with academic rewards including research grants, awards and T&P guidance and guidelines.

Theme 4: Digital Inequity

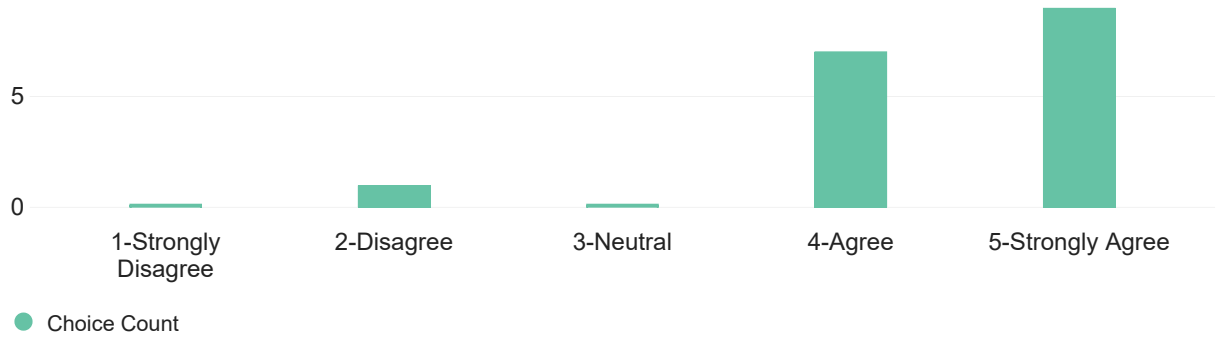
Background: Students and faculty possess different levels of digital literacy, and students' social, economic, and disability status interact with their digital literacy and digital inequity. Deficiencies in digital literacy are shown to be a hindrance to students' success. In addition, skills such as digital adaptability are a relatively new concept in AEC education. It is urgent that AEC programs foster such transferable skills of students in learning digital technologies to achieve equitable learning outcomes and develop a holistic view of digital inclusion (including physical access to digital technologies and the entire teaching and learning ecosystem).

Specific challenges are:

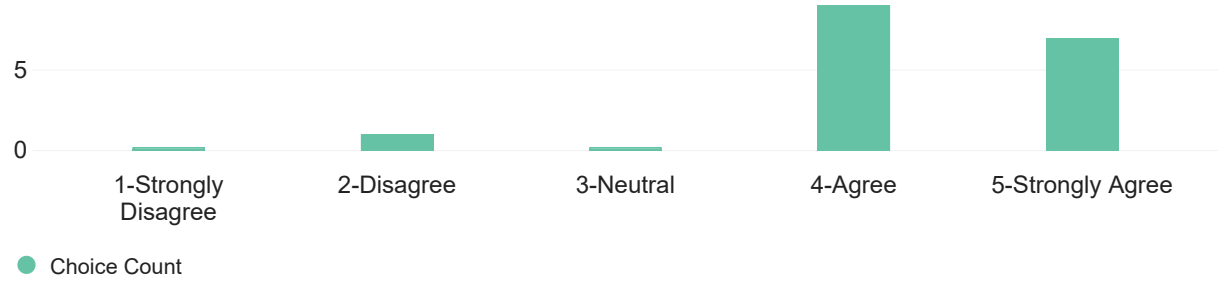
1) How AEC programs use technology-enabled education to achieve equitable outcomes.



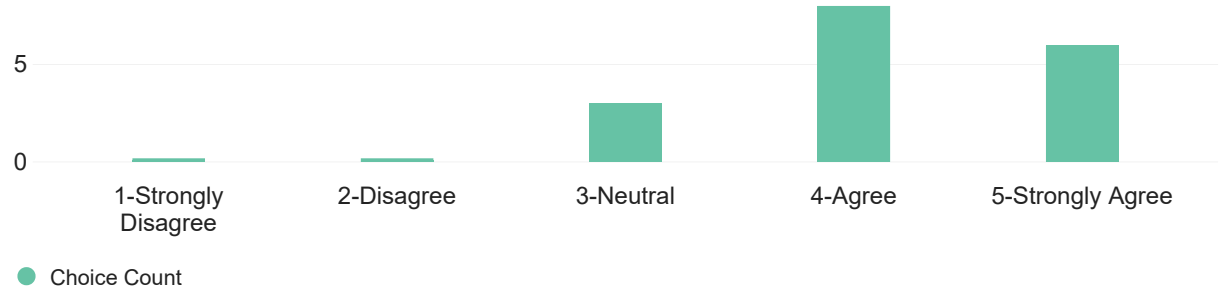
2) What constitutes digital adaptability for AEC students, especially those in underserved communities.



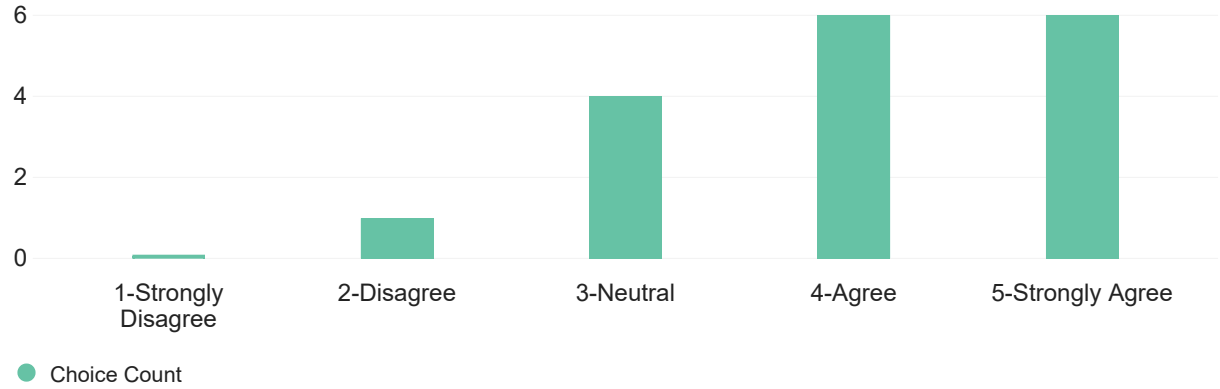
3) How AEC programs create a mindset of students committing to continuously developing such transferable skills to meet challenges due to evolving AEC education and industry practice.



4) How AEC programs foster transferable skills in learning digital technologies.



5) How AEC programs develop a holistic understanding of digital inequity in AEC education.



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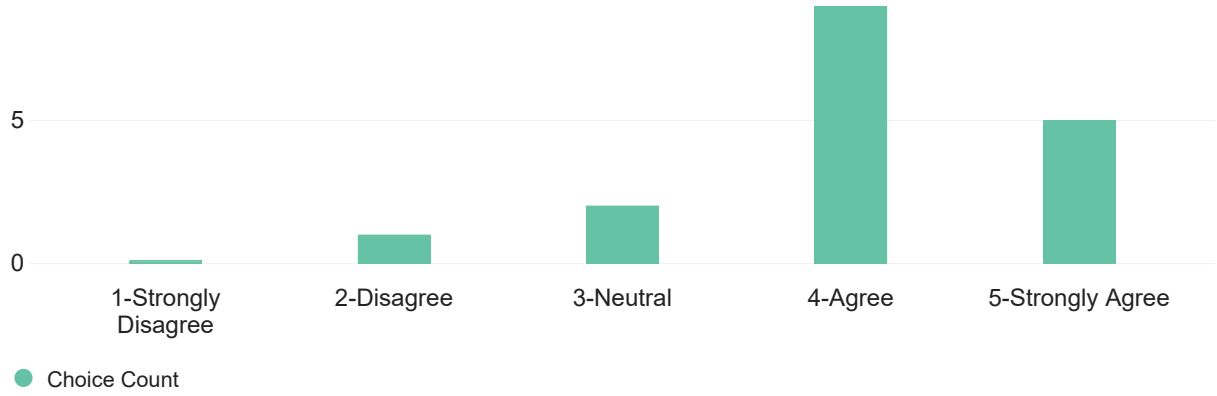
6) How AEC programs develop a holistic understanding of digital inclusion in AEC education.



7) Please list other relevant challenges or comments:

7) Please list other relevant challenges or comments:

These address some of the points I had mentioned on a prior entry, I didn't realize that we would get to these points eventually when replying under the first theme.

None.

Find ways that faculty can stay abreast of , develop and maintain expertise in the use of digital tools. These tools are far more involved than casual use can equip faculty members.

Specific actions are to:

1) Explore concepts, theories, and methods for building AEC learners' digital inclusion, digital fluency, and digital adaptability.

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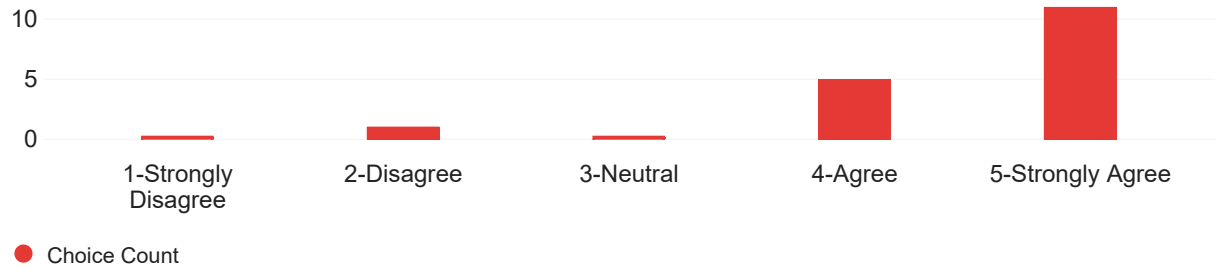
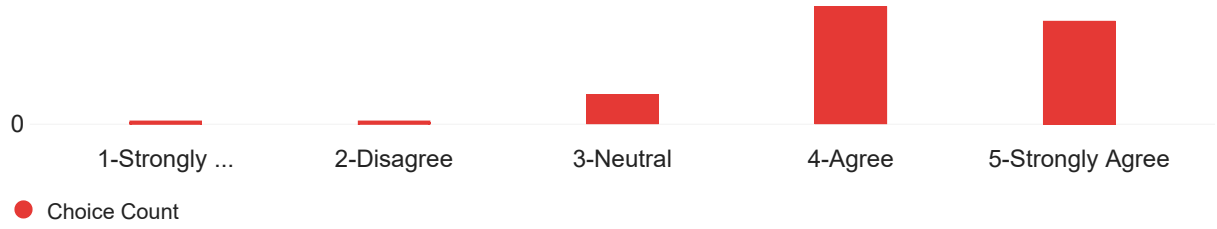
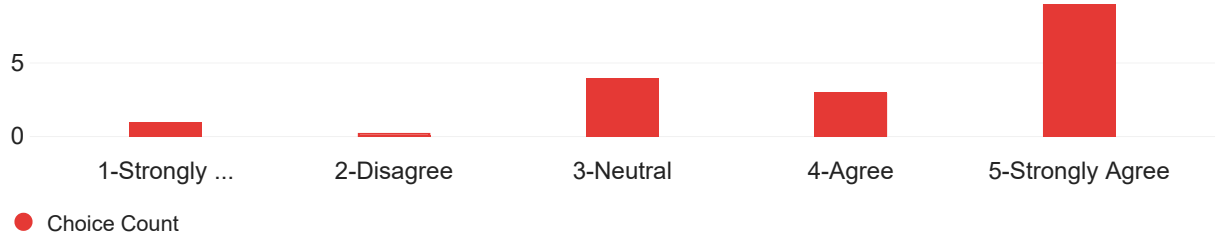
2) Develop, in addition to digital literacy, media literacy, and information literacy skills, an equally important growth mindset and self-directed learning habits to tackle challenges and opportunities presented in the digital age.



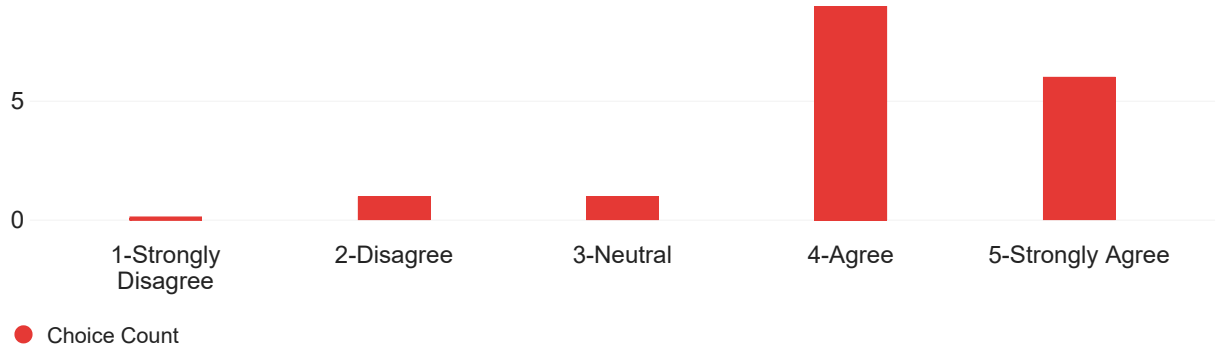
3) Develop a continuous discourse in AEC education about the evolving processes and technology norms in the industry to allow students to focus on building their confidence and attitudes and develop the core skills and understanding necessary to succeed.



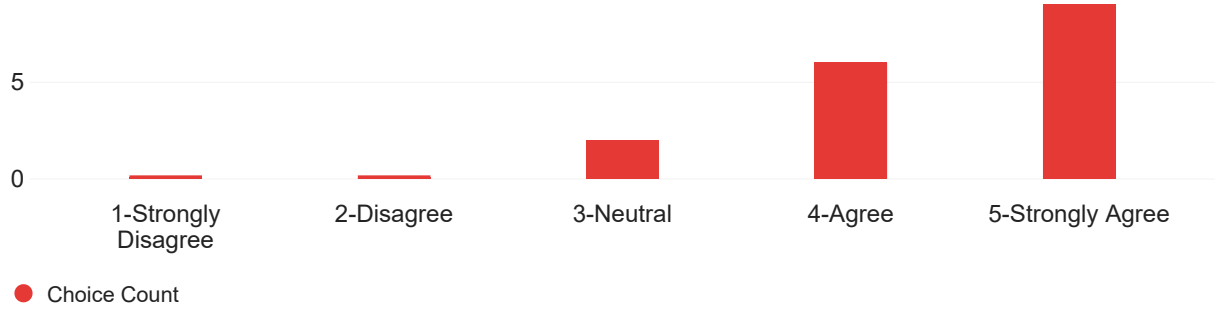
5) Create an inclusive community of practice and learning that applies principles such as user-centered design (UCD) to change what we teach and how we teach, for example, the involvement of underserved students in ideation, assessment, and testing alternatives.



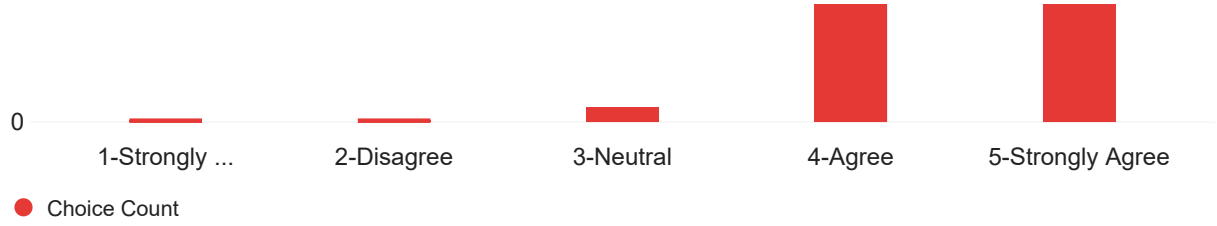
6) Individualize teaching/learning delivery according to the conditions of each student.



7) Create pedagogically sound approaches to support lifelong learning, for example, supporting learners with micro-credentials and offering technology-enabled learning opportunities for such learners.



8) Develop holistic approaches to address digital inequity in education for students with disabilities, for example, considering 1) access to hardware, software, and the internet, 2) accessibility of teaching and assessment tools, and 3) attitudinal barriers of faculty members.



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9) Please list other relevant actions or comments

9) Please list other relevant actions or comments

As mentioned before, it also relates to social familiarity and understanding of the affordances of various technology and may involve recognizing forms of expertise or experience that some groups may have developed through informal activities that are relevant for bridging or enriching digital understanding and use.

None.

We need to better support underserving populations if we want to have a more equitable and collaborative industry.

APPENDIX III: WORKSHOP 2 PROGRAM

Thursday, June 23, 2022 - Registration

Local Time	Topic	Activity
3:00 – 5:00 pm	Registration	Registration is open.

Friday, June 24, 2022 – Day 1 of the Workshop

Local Time	Topic	Activity
7:00 – 8:00 am	Breakfast and Registration	
8:00 – 8:15 am	Welcome Note	Dr. Yimin Zhu
8:15 – 9:00 am	Theme Group Discussion Framework	To ensure the key deliverables are obtained at the end of Day 1 and are ready to be framework for Day 2 discussion. ▪ Define Roles for Theme Discussions ▪▪ Leader (assigned for the day) ▪▪ Scribe (rotates each time) ▪▪ Reporter (rotates each time) ▪ Define Tasks for Theme Discussions ▪▪ Review Workshop 1 challenges and actions ▪▪ Determine if anything is missing or needs clarification ▪▪ Provide stickies ▪▪ Determine top 2 ▪▪ Complete SIPOC ▪ Define Expected outcomes ▪▪ Prioritized actions to take for theme ▪▪ Documented SIPOC for top 2
9:00- 9:30 am	Keynote Speech	Dr. Alexandra Medina-Borja from the National Science Foundation
9:30 – 11:00 am	Group Discussion	Theme 1: AEC Curricula & Industry Practice
11:00 – 11:15 am	Break	15 min
11:15 – 12:45 pm	Group Discussion	Theme 2: Technology and Learning
12:45– 1:30 pm	Lunch Break	60 min Lunch Break
1:30– 3:00 pm	Group Discussion	Theme 3: Interdisciplinary Education
3:00 – 3:15 pm	Break	15 min
3:15 – 4:45 pm	Group Discussion	Theme 4: Digital Inequity
4:45 – 5:00 pm	Wrap Up for Day 1	Summarize Day 1 and Preview Day 2

Saturday, June 25, 2022 – Day 2 of the Workshop

Local Time	Topic	Activity
7:00 – 8:00 am	Breakfast and Registration	
8:00 – 8:30 am	Report on Day 1 Discussions	Bao Do, MetroState IPD Facilitator Provide findings and Day 2 approach
8:30 – 9:10 am	Building Consensus on Theme 1	Bao Do, MetroState IPD Facilitator Group reports and whole group discussion
9:10 – 9:50 am	Building Consensus on Theme 2	Bao Do, MetroState IPD Facilitator Group reports and whole group discussion
9:50 – 10:00 am	Break	10 min break
10:00 – 10:40 am	Building Consensus on Theme 3	Bao Do, MetroState IPD Facilitator Group reports and whole group discussion
10:40 – 11:10 am	Building Consensus on Theme 4	Bao Do, MetroState IPD Facilitator Group reports and whole group discussion
11:10 – 11:45 am	Create Roadmap Complete Evaluations	Bao Do, MetroState IPD Facilitator Facilitate group thru phasing of action items ▪ Discuss top action plan votes ▪ Are there any affinity clusters? ▪ Based on SIPOC, what is needed?
11:45 am – noon	Wrap Up for Theme Discussions	AEC Project leaders discuss next steps for the information. Dr. Amir H. Behzadan, Texas A&M University Dr. Raymond Issa, University of Florida Dr. Yimin Zhu, Louisiana State University Dr. Amirhosein Jafari, Louisiana State University
Noon – 2:00 pm	Lunch Break and Discussions for Future Activities	

METRO STATE UNIVERSITY
Institute for Professional Development

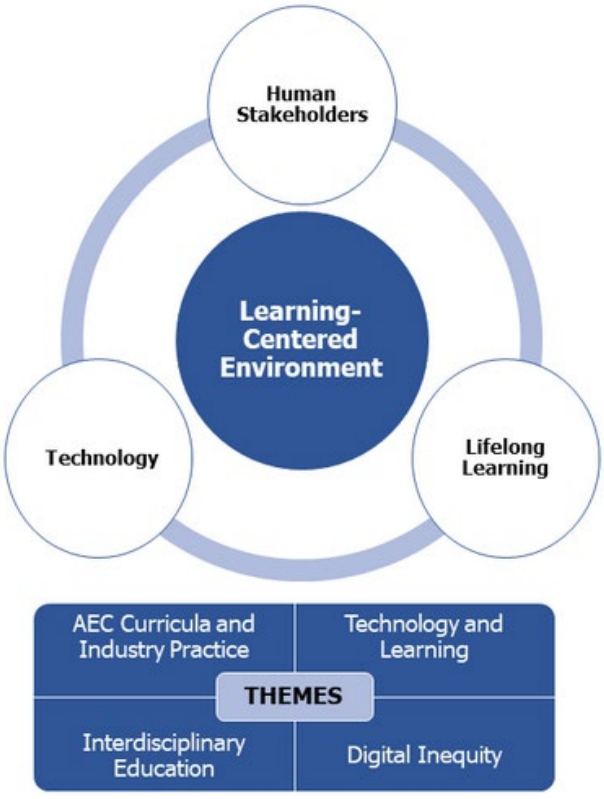
Architecture, Engineering, and Construction Education (AEC)

Workshop: Next Generation Learning-Centered Environment

Problem/Opportunity

Provide a facilitator to achieve the workshop goal of creating a shared vision of the next generation learning-centered environment for AEC education through exploring the relationship among humans, learning, and technology in varied social contexts.

The four main themes of this project are:



AEC Curricula and Industry Practice: The human-technology frontier in AEC workplaces is changing in many fundamental aspects, particularly in these unprecedented times of a global health pandemic. Thus, it is important to answer questions that are critical to shaping the future of AEC education, e.g., what are the gaps between AEC curricula and industry practice, and what is the role of emerging technologies in creating and/or closing these gaps?

Interdisciplinary Education: Multidisciplinary teamwork and communication are essential skills for AEC students. Opportunities offered by emerging technologies have not been fully explored, such as new pedagogical strategies to deliver interdisciplinary learning content that is conducive to multiple disciplines.

Technology and Learning: Technology-mediated learning, including technology-generated artifacts, such as 3D design models or construction site images, affect learning. Fundamental questions will be explored related to how emerging technologies, coupled with advancements in cognitive and education sciences, form disruptive forces to improve the learning environment.

Digital Inequity: The AEC education communities have widely embraced the use of computer technologies in both in-person and online learning. Thus, it is important to understand the extent and influence of digital

inequity while creating technology-intensive learning environments, and address grand challenges by developing new pedagogical strategies.

Each theme already has 4 – 6 challenges defined and 8 – 10 actions defined.

If selected for facilitation, additional information from Day 1 workshop would be provided to the facilitator.

Solution

Envision the future of AEC education by coming to consensus on the challenges and related actions for each theme. This will provide the ground work for AEC to build a roadmap for collaboratively addressing challenges and being effective educators for Architecture, Engineering, and Construction.

For each theme,

1. The small group will discuss the challenges and add if needed
2. The small group will discuss actions and add to them if needed.
3. The small group will connect actions to challenges.
4. The small group will prioritize and share their challenges and actions.
5. The large group will reach consensus on prioritizing the challenges and related action steps.

Prior to the workshop,

- AEC will assign participants to small groups for diversity of expertise and institution.
- Participants will arrive with a familiarity of the 4 themes, the existing list of challenges for each them, and the existing list of activities for each theme.

During the workshop on Day 1:

- Facilitator will arrive and be set by 8 am.
- The facilitator will engage faculty from a wide range of institutions (two-year, four-year, research, predominantly undergraduate, minority-serving, etc.) as well as professional society members and practitioners in AEC and related information technology industries to discuss each theme's challenges and action steps.

Following the workshop on Day 1:

- Facilitator will capture small group outputs with photos of their discussion products.
- Facilitator will aggregate and synthesize those results to prepare of Day 2 discussion.

During the workshop on Day 2:

- Facilitator will engage participants to reach a consensus on the prioritized challenges and related actions steps for each theme.
- Facilitator will capture this information with photos.
- Facilitator will pack up and tidy so that the room is ready for after lunch discussions.

Name: Quoc-Bao Do (goes by Bao)

Expert Areas:

- Business Architecture
- Business Analysis
- Program/Project Management
- User-Centered Design
- Coaching/Mentoring/Development

Education/Professional Certificates:

- Business Architecture Certificate from Metropolitan State University – St. Paul, MN
- Certificate of Human-Centered Design from LUMA Institute
- Bachelors of Arts in Psychology from University of Michigan

Relevant experience to topic areas:

- 11+ years of Business Architecture
- 15+ years of Business Analysis
- 10+ years of Project Management
- 5+ years of Design Thinking

Philosophy of training in a nutshell:

Form, Function, and Fit

Instructor Bio

Bao Do is a LUMA trained and certified facilitator. He uses their techniques of Human-Centered design or design-thinking to generate solutions from collaborative thinking. He will bring a straight-forward facilitation approach to the workshop that creates the safe space for people to share. His activities will encourage creative thought on Day 1 and guide the group to consensus on Day 2.

While by day, Bao works for Wells Fargo financial institution, he would bring an understanding of business analysis and project management that would connect and resonant with the experts in the room.

In addition, Bao's business architecture expertise is an asset. Business architecture is taking an enterprise-wide look at the current state, envisioning the future state, and determining the execution steps needed to bridge the cap between the two. Ultimately, the workshops for AEC are doing this same business architecture work. Bao has facilitated 4-hour business architecture workshops to have groups reach consensus.

Agenda

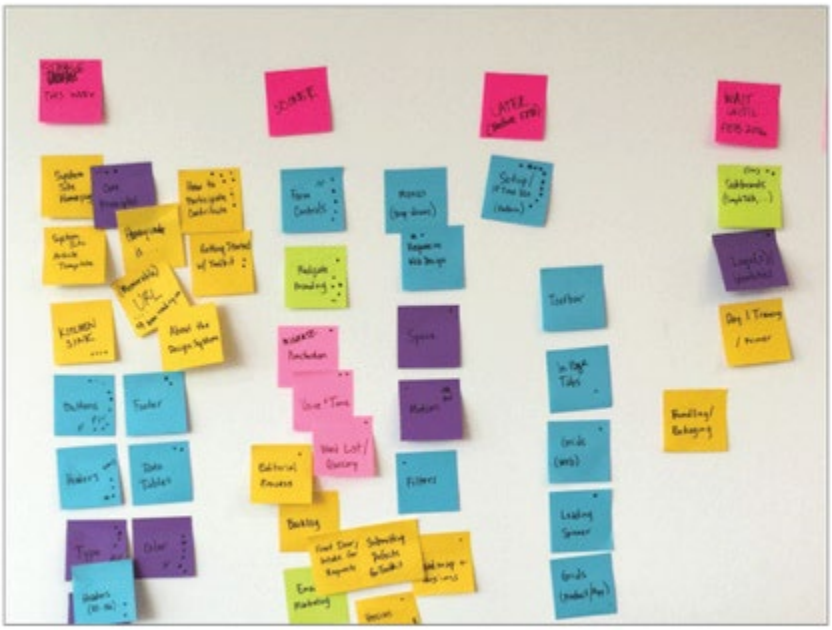
A more detailed agenda would be developed in conjunction with event leadership. Some the timing will depend on the final number of groups and report outs.

Local Time	Topic	Activity
8:00 – 8:15 am	Welcome Note	Dr. Yimin Zhu
8:15 – 9:00 am	Keynote Speech	Dr. Alexandra Medina-Borja from the National Science Foundation
9:00- 9:20	Discussion Expectations, Guidelines, and Outcomes	To ensure the key deliverables are obtained at the end of Day 1 and are ready to be framework for Day 2 discussion. ▪ Provide guidelines on how to identify challenges and action item criteria to ensure reasonability ▪ Provide guidelines for each group on self-organizing roles and required documentation ▪ Provide expectation that discussions must provide outcomes: ➢ List of challenges / action items ranking
9:20 – 4:45 Times for breaks and lunch	Generation of Challenges and Action Items	Work in groups using the provided guidelines to produce the key deliverables. Facilitator will circulate to help groups where discussion is waning or need assistance producing key deliverables
4:45 – 5:00 pm	Wrap Up for Day 1	Summarize Day 1 and Preview Day 2

Local Time	Topic	Activity
8:00 – 10:45 Time for Breaks	Presentation of theme challenges and activities	Have the presenter from each group provide their key deliverables for theme 1 from Day 1 Discussion. Use affinity mapping after each presenter to track and group information. Repeat for each theme.
10:45 – 11:45	Create Roadmap	Use dot voting for prioritizing in the large group. Facilitator will lead a large group exercise to sequence the themes into an umbrella road map
11:45 am – noon	Wrap Up for Theme Discussions	Perhaps the AEC Project leaders want to discuss next steps for the information.

Sample of affinity mapping with dot voting

Sample of umbrella roadmap*



PARTS ORGANIZED BY NOW, SOONER, LATER, & WAIT

* Discussions with leaders prior to the workshop would determine if an umbrella roadmap is needed. Maybe the dot voting produces the priority list and those concepts are numbered on the affinity diagram to highlight the group's thoughts. Or maybe an umbrella roadmap with a timeline. The facilitator is flexible on delivering what you need for your next phase. Project leadership defines the final outcome.

Facilitation Investment Scope and Deliverables

Facilitation investment for 40 participants includes:

- 1.5 days of facilitation from a qualified facilitator
- Travel expenses for the facilitator
- Meeting to gain information to write a facilitation proposal (already completed)
- Meeting to review facilitation outline and agenda
- Meeting to review final activities and approve agenda
- Visual aids, supplies, and handouts used by the facilitator
- Name tents (with group ID if that is helpful)
- Evaluations – administered, aggregated, and analyzed for lessons learned feedback – especially about the process used
    - Note that our evaluations can include some questions that your team would like to gather and have aggregated anonymously
- Photographs of small group artifacts
- Aggregation of Day 1 information to be ready to start Day 2 discussions
- Photographs of the final consensus of prioritized challenges and related actions steps for each theme

Out of scope of facilitation investment:

- Providing the information to the participants prior to the workshop day
- Summarizing/teaching the research
- Putting participants into theme groups

Investment $5990.00

Contact

Beth Schaefer
Director, Institute for Professional Development
O- 651-999-5834
M- 612-508-8875
Beth.schaefer@metrostate.edu
www.MetroStateIPD.edu

APPENDIX V: LARGE GROUP ACTION VOTES