

Is the AEC profession a good fit for me? A Constructivist Grounded Theory on Professional Identity Formation in First-Year Architecture, Engineering, and Construction (AEC) Women

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Is this AEC profession a good fit for me? A Grounded Theory on Sparking Professional Identity Development in First-Year Architecture, Engineering, and Construction (AEC) Women

Abstract

Women professionals are underrepresented in the architecture, engineering, and construction (AEC) industry. As part of a larger and longitudinal nationwide study that constructs grounded theories to explain professional identity development (PID) processes in undergraduate AEC women, the purpose is to examine the lived experiences of first-year AEC women. Using purposive sampling, 40 AEC women from five institutions completed surveys with open-ended questions about salient first year experiences. Also, resumes and academic transcripts were obtained. Adopting the grounded theory approach and constant comparative analysis, data was analyzed using the NVivo Qualitative Analysis software for coding, categorization, and theme development.

Data analysis reveals a critical question on the minds of first-year AEC women: *Is this AEC profession a good fit for me?* Utilizing four categories and twelve subcategories, an emerging theory, *Sparking AEC-PID Through Agency and Networks*, highlights the role of interactions between self and structures in forming AEC-PID and influencing women persistence in undergraduate AEC programs. This theory proposes important predictors of AEC-PID and AEC persistence in women. It captures cognitive, emotional, physical, social, and academic processes that spark AEC-PID in women. Positive interactions between self and AEC program environments strengthen AEC-PID because of improvement in AEC knowledge, views, mindsets, and efforts to explore niches for progression in undergraduate AEC programs and towards AEC professions. However, the lack of gender diversity remains a concern. Also, heavy workloads and unfavorable program conditions cause stress, particularly in Architecture women. These negative interactions weaken AEC-PID because they result in declining views about the AEC profession. Therefore, women persistence in undergraduate AEC programs requires developing the ‘survival’ mentality and spurring the super woman mindset. While medium to strong AEC-PID sustains the desire to persist in many *Prevailing* women, medium AEC-PID is also associated with lowered desire to persist as a few *Hesitant* women become open to other careers options. Excessively negative interactions erode AEC-PID and the desire to persist, as one *Yielding* woman plans her AEC program exit. It is critical that undergraduate AEC women are provided early AEC gateway experiences that assure them that AEC programs and professions are a good fit for them. Insights have theoretical and practical implications towards transformations that will strengthen the attraction, preparation, and retention of the next generation of AEC women. In the long term, this would reduce AEC workforce shortages and foster the innovation of more gender friendly AEC products and services.

INTRODUCTION

In addition to workforce shortages and the lack of racial diversity in the architecture, engineering, and construction (AEC) industry, women are severely underrepresented in AEC professions. With projected employment growth in the AEC industry, there are serious nationwide concerns about these workforce shortages [1-4]. Even though talented women could

help resolve this crisis, women are still the most untapped population for the next generation of professionals in STEM [5][6]. Women are less than 10% of the construction workforce with professionals being less than 5% [7]. Compared to being about 50% of the world's population, these statistics are concerning. Rather than the lack of cognitive ability, women underrepresentation is attributed to socializing and learning processes which do not encourage interests in AEC careers [8-10]. Negative imagery of dirty hands and old boys' networks, as well as negative female experiences and cultural stereotyping discourage AEC career choices in girls [11]. Although wide gender gaps in STEM disciplines such as Biology have been minimized, women continue to remain underrepresented in AEC professions. Interventions that proved effective in bridging gender gaps in some STEM professions are not as effective in AEC professions because they are not robust enough to overcome differences in educational and professional environments.

Undergraduate AEC programs prepare students for the design and development of buildings and infrastructure. Beyond AEC curricula, extracurricular programs and professional experiences enhance interests and persistence of college students into AEC careers [12-15]. Notably, women are also underrepresented in AEC academic environments. Effective transformations in pre-college and college educational and professional environments could improve the persistence of women towards AEC professions [12][13]. Identity theorists advocate that understanding professional identity development (PID) processes in students could inform interventions improve student persistence into professions [16]. Effective learning experiences could improve AEC-PID in girls and women [9][17]. The combination of AEC professional experiences and AEC industry views revealed four increasing levels of nascent AEC-PID in first-year AEC women: Plain, Passive, Progressive, and Proactive. These inform tailored interventions to support persistence in AEC programs [17]. Nevertheless, there remains a lack of empirical knowledge and understanding of AEC-PID processes in undergraduate AEC women. Women are underrepresented in AEC, STEM, and PID studies, making it difficult to extend existing theories to AEC women populations [8]. The current theory-practice gap existing in several male-dominated undergraduate programs can be reduced with AEC-PID research exploring the process of internalization whereby undergraduate women students come to think, act, and feel like professionals. Empirical research on AEC women can guide the design and implementation of more tailored and effective interventions that will strengthen AEC-PID in undergraduate women.

THEORETICAL FRAMEWORK

This research relies heavily on psychology and sociology literature that support professional identity development in students [16]. PID is the process by which students come to think, act, and feel like professionals [18]. It involves the successful integration of personal attributes and professional training in the context of a professional community. PID is a dynamic and complex process that involves the continuous interpretation and re-interpretation of experiences which foster the strengthening and maturing of an individual through a series of educational and professional experiences [19-21]. A variety of factors associated with educational and professional environments influence the formation, evolution, and progression of PID in an individual [9][18][22]. Professional identities in STEM students continue evolve as multiple identities of students interact with academic and professional environments [22]. Four

perspectives of identity include: (1) nature identity; (2) institution identity; (3) discourse identity; and (4) affinity-identity [23]. Gee's model guides explorations involving interactions among multiple student identities, academic and professional environments, and institutional contexts as students transition into thinking and feeling like professionals. There is no doubt that the beliefs, values, wants, and views of students regarding what they want to become influences how they interact with related structures and contexts [24]. Identity development is influenced by socio-cultural environments as students are shaped by the structures, forms, activities and events that occur within these environments [25]. Conceptually, PID is congruent with the different processes that influence identity development as individuals progress through life and organize their experiences into a meaningful whole that involves personal, private, public and professional identities [18][26-28]. Identity formation is complex during transitions from infancy into adulthood and are represented by individual, relational, and collective domains [29]. Personal characteristics and beliefs are in the individual domain, family and friends are in the relational domain, and social groups are in the collective domain [18][29].

Drawing from these theoretical foundations, it can be inferred that following enrollment, first-year AEC women begin to interact with AEC academic, professional, and institutional environments. Dynamic and complex interactions with multiple identities evolve during formative years and progresses over time until AEC professional identity matures [12]. Considering that women are underrepresented in AEC, it can be inferred that there are gender gaps between pre-college experiences that make men have smoother transitions into undergraduate AEC programs. Within male-dominated AEC learning environments, women are expected to implement coping strategies to adapt and enhance the successful development of their AEC-PID [30]. Consequently, AEC educational and professional communities continue to seek knowledge and understanding to guide improvements in policies and practices that will increase women representation and participation in AEC programs and AEC professions.

PURPOSE

As part of a larger nationwide and longitudinal study to develop substantive theories on PID processes in undergraduate AEC women, the purpose of this research was to examine the salient lived experiences of first-year AEC women. With limited research on undergraduate AEC women, the uniqueness of this research lies in its gender and industry contexts and has the potential to expand existing STEM identity theories, which typically focus on male students.

METHODOLOGY

With preference for the symbolic interactionist theoretical approach which allows the researcher to co-construct theories that are grounded in the implicit meanings and experiential views of RPs, the Charmaz constructivist Grounded Theory methodology is utilized in this study [31-33]. This methodology has been utilized in a few engineering education research. Purposive sampling is used to recruit 40 undergraduate AEC women enrolled in freshman AEC courses in five U.S. institutions. These institutions are diverse in location, predominantly white institution (PWI)/historically black college/university (HBCU) status, accreditations, and AEC programs. Research Participants (RPs) complete Qualtrics-based surveys with open-ended questions. For methodological triangulation, academic transcripts and resumes are obtained to gain insights into

academic, professional, and social experiences. Recruitment forms provide demographic and personal data. Utilizing constant comparative analysis, data was analyzed using the NVivo software for coding, categorization, and theme development. The frequency percentage of each sub-category or category is calculated by dividing the number of RPs who made statements coded to that sub-category or category by the total number (40) of RPs in this research study and multiplying by 100. Only categories with high frequency percentages were utilized for theory development. Sub-categories were included if at least 10% of the research participants made statements coded to that sub-category.

Characteristics of RPs

Majority of RPs are from Architecture and Engineering programs as shown in figure 1.

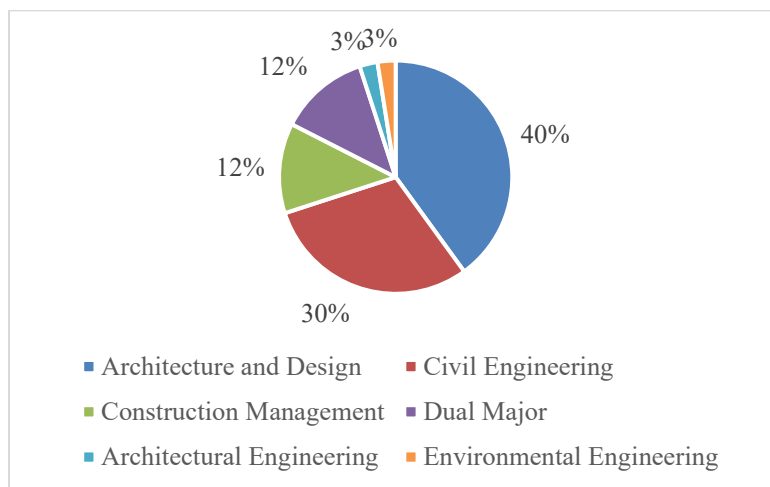


Figure 1: AEC Programs

Women with a variety of racial backgrounds are represented in this research population, with majority being African Americans and Whites as shown in figure 2.

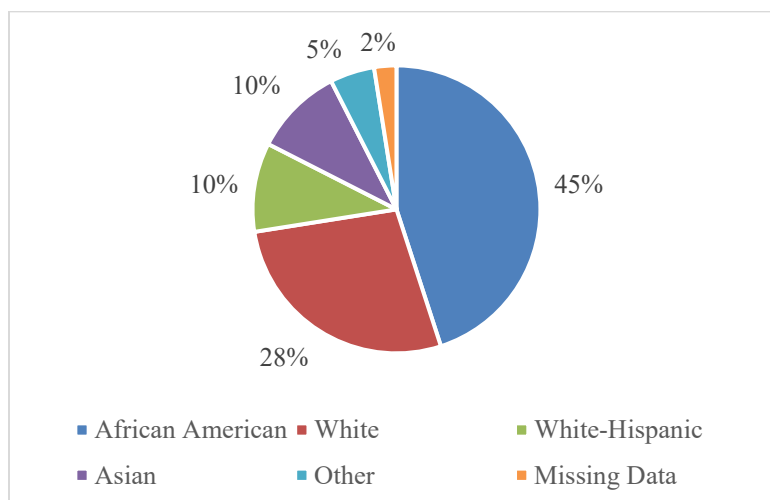


Figure 2: Race

Women with a variety of annual household income are represented in this research population, as shown in figure 3.

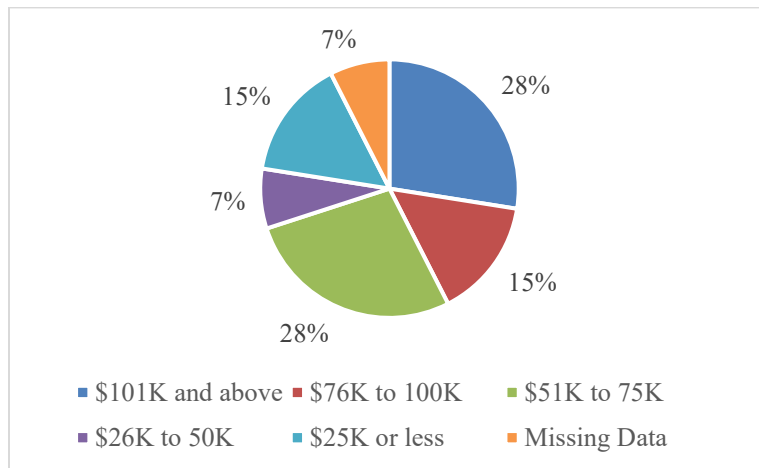


Figure 3: Annual Household Income

RESULTS

An emerging theory, *Sparkling AEC-PID Through Agency and Networks*, highlights the role of interactions between agency (self) and networks (structures) in igniting AEC-PID and influencing the persistence of first year women in AEC programs as explained with 4 categories and 12 subcategories (Figure 4). The four categories are: (1) Prioritizing Agency; (2) Prioritizing Networks; (3) Sparking AEC-PID; and (4) Propelling Female AEC Student Self.

CATEGORY 1: PRIORITIZING AGENCY

One hundred percent of RPs made statements expressing how they prioritized important interactions between AEC learning experiences and their own personal characteristics, strengths, and values. Both positive and negative experiences were highlighted in the following four sub-categories that contributed the PRIORITIZING AGENCY category:

SUB-CATEGORY 1.1: Knowing Core Self “KNOWING YOURSELF”

Eighty percent (80%) of RPs made statements regarding knowing core self. They addressed personal strengths (70%) and limitations (33%).

Strengths: Strengths were primarily inherent abilities to include being creative, driven, competitive, hardworking, sociable, and loving challenge. The favorite subjects of first-year AEC women include science, math, and art; and they enjoy visual/performing arts and sports [17]. The utilization of these natural strengths in AEC learning brought fulfilment and assurances regarding AEC program choice. Knowing strengths enhanced perceptions of congruence between self and the AEC profession as explained by an Architecture RP, “Time management and knowing yourself are also major keys. You will need to push yourself, but also be aware of your limitations. I would recommend architecture to anyone who enjoys art and is looking for a secure job that will use elements of art in it. Some of the classes may be more difficult than

others but it is important to push through because it will pay off in the end. Architecture is the perfect profession to express your creativity in a way that others will be able to enjoy. I have only just started my architecture classes, but I know that it is the right profession for me and will allow me to express myself.”

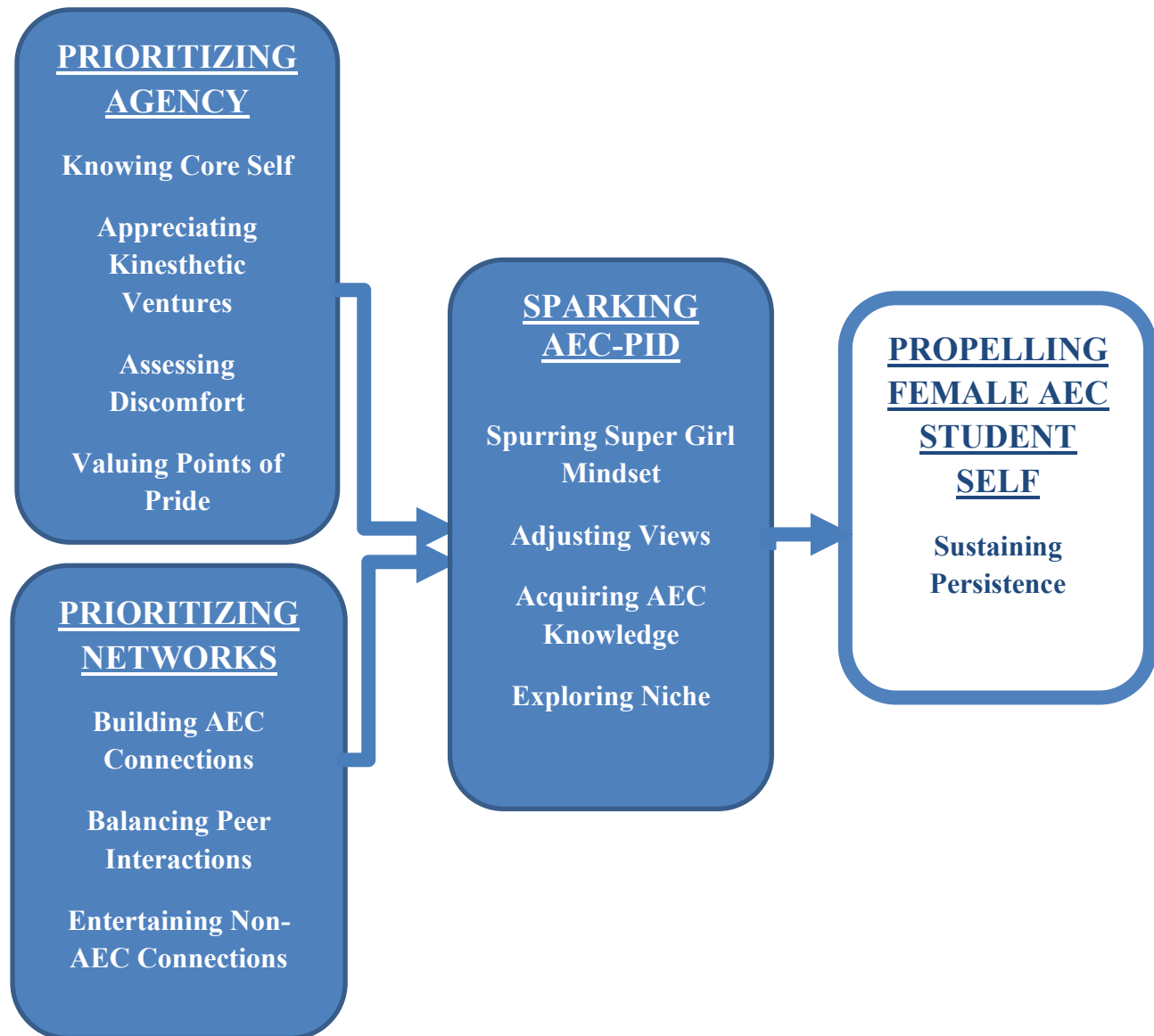


Figure 4: The ‘Sparking AEC-PID Through Agency and Networks’ Model

Limitations: Few RPs made statements about limitations such as not being good in drawing and not being sociable. These questions tend to make RPs doubt their fit in the AEC career pathway. RPs sensed that these limitations would reduce their chances of success. Therefore, knowledge of limitations stirred up the urgent need to access important resources and support such as tutoring to overcome limitations and persist in the AEC major. An Architecture RP, “I’m excited to start this semester and get into architecture theory and start learning three-dimension design

and perspective. I'm nervous cause I've never been good at drawing in any style other than two-dimensional. There is an architecture exclusive library with computers free to use with any drafting and modeling program we could need... I am taking an architecture theory/intro design class this semester. It's lecture style and encourages us to free draw and come up with building designs in our free time and bring them to the class to be peer-reviewed in small groups." RPs understood that overcoming these weaknesses were critical for the academic and professional success. As long as RPs feel that resources and support are adequate and can help them overcome their weaknesses, they are likely to persist in the AEC program.

Being able to align core strengths with AEC learning experiences is critical for assuring first-year AEC women that they made the right career decision, making it an important predictor of AEC-PID.

SUB-CATEGORY 1.2: Appreciating Kinesthetic Ventures "BEHIND-THE-SCENES PEAK"

Seventy-five percent (75%) of RPs made statements related to kinesthetic ventures. They addressed hands-on (58%) and experiential (38%) learning.

Hands on Learning: Hands on activities such as building models in AEC classrooms, labs, and studios, were fun as RPs engaged their creative strengths and established connections with AEC program requirements.

Experiential learning: Experiential learning occurred primarily through internships. Considering that RPs were freshmen, only a few RPs had internships. Internships provided opportunities to engage in real-life AEC professional experiences to validate decisions to pursue AEC professions. RPs with internship experiences felt strong connections between their abilities and AEC professional roles and these verified AEC career decisions as explained by an Architecture RP, "...Most of my hobbies are individual activities such as drawing ... Towards the end of the semester I started an internship at the construction office on campus. The people I work with have been introducing me to what a day in the life as an architect might be like...I have always known that I would enjoy doing architecture. If anything, I feel more sure of my decision to pursue architecture because of my internship." The intrinsic motivation and passion for AEC careers are advanced through such experiential learning engagements. Recognizing the importance of experiential learning on real-life AEC projects, one RP recommended that AEC departments host their own career fairs to increase internship opportunities. In the absence of full internships, externships and job shadowing opportunities can be beneficial as highlighted by a Civil Engineering RP, "Recently, I was a part of the Externship Program through the School of Engineering. It essentially is a mini-internship where you spend the day shadowing a professional just like an intern. I was assigned to [AEC Company], and shadowed an amazing civil engineer who was partly in charge of a construction site. I got to spend the day in meetings, talk to contractors, and even survey the construction site, which was beginning the last stages of construction: walls, wiring, and lots problems arising. It was enlightening to talk to the people who actually build the parts of a building and to get real hands-on experience. I feel like it is difficult to be a good engineer without having some sort of functional knowledge of what it takes to implement your design, so I was happy to take a sort of behind-the-scenes peek at what

actually goes into a construction site. It was also nice getting a look into the construction side of civil engineering.”

While most buildings and infrastructure may be generally observed by the public, through academic and industrial kinesthetic engagements RPs gained additional in-depth insights into the rarely observed and hands-on aspects and processes related to the design and development of AEC products. These increased their interests and AEC-PID as they felt fulfilled as their abilities were being utilized in the development of AEC models and/or real-life AEC products such as buildings and infrastructure. Passion for kinesthetic AEC academic and industrial experiences assured RPs that they were pursuing the right profession, making it an important predictor of AEC-PID.

SUB-CATEGORY 1.3: Assessing Discomfort “SURVIVING”

Ninety-five percent (95%) of RPs made statements related to their discomfort in undergraduate AEC educational environments. Discomfort was categorized as academic (73%), psychological (53%), physical (25%), diversity (25%), financial (20%), and social (18%).

Academic Challenges: These negative academic experiences included difficult course requirements, heavy workloads, inadequate learning experiences, and delayed introductions to AEC professions. Inadequate learning experiences were associated with lack of real experiences, excessively high professor expectations, poor professor teaching, and crushing reviews from professors. Also, some freshmen were dissatisfied with the fact that there were no or minimally effective AEC courses in the first-year curriculum and this limited their understanding and connection to AEC career roles. They needed some assurances about their career choices and felt that effective gateway AEC courses would provide them with opportunities to evaluate their AEC career decisions. An Architecture RP explained “During my Fall semester at [Institution], I didn’t get any hands-on learning experience in Architecture. I was vaguely introduced to Architecture through a first-year seminar class for the Fine Arts students named [Course Number]. The class had over 50 students and the instructor broke us up into groups and every two weeks we rotated from teacher to teacher. There were five teachers: architecture, art, theatre, film and dance. So for two Fridays, in a class about four hours long, I sat in an Architecture class with other students in the Fine Arts program and listened to a teacher introduce what Architecture was, in his own words... I was mostly concerned with if I would be ready to jump into Architecture classes. I felt a little unprepared because I was only taking my pre-requisite classes. My thing is, I didn’t really know what to expect for the spring once I was going to actually be enrolled in Architecture classes. I also had a concern with if Architecture was the right program for me. I know that it is something that I want to pursue, but I didn’t know what it would take to be an Architecture student at [Institution].” An analysis of academic transcripts revealed that 38% of the 29 transcripts had no AEC courses and 41% had one AEC course. While non-AEC and General Education freshman courses were enlightening, their preference was for freshman AEC courses for early exposure, sustained interest, and timely affirmation of chosen careers. An earlier introduction to AEC roles through first year and first semester AEC courses would validate career choice decisions as students would have greater opportunity to assess whether there was a good fit between their current AEC student self and their future AEC professional self.

Physical Challenges: Negative physical experiences included all-nighters and time-consuming projects which reduced sleep and increased tiredness, especially in Architecture RPs. These necessitated self-regulation strategies to include time management. An Architecture RP explained, “A typical day in the AEC program would consist of a studio class in the morning for Architecture divided in two parts: lecture and studio. After the lecture given by the professor(s), I would head straight to the studio and either begin on the new task at hand or quickly tidy my desk so that I could start on a clear working space. After variations of sketches and messily-put-together sketch models, after class would end, I would either grab something quick to eat or head straight to my next class. After all my classes are finished for the day I would either head to work or return to my dorm. On a day that I was not going to work I would go to my dorm for a bit of down time to relax from the events of the day and would most likely return to studio to finish an assignment that was assigned and due the next class. Depending on the difficulty of the assignment, I would either find myself pulling an “all-nighter” or managing to finish on time. Unfortunately these were longer nights than short which caused drowsiness due to lack of sleep which was present during my other classes when I would begin to doze off.”

Diversity Challenges: RPs expressed concerns about lack of gender and racial diversity in AEC programs and professions. This resulted in a sense of isolation. A Civil Engineering RP explained, “The moment I walked into my engineering class, I was immediately overwhelmed by the male to female ratio. There were very few females in the room. The males automatically grouped, and it left the girls to pair up with each other. I felt that it became a male vs. female competition.” Both gender and racial minority concerns were raised by a Construction Management RP who noted that, “Some of the concerns that I have about my AEC program would be the respect of other male classmates. It is prevalent that the respect is low for us women in our program. Also, some of the professors’ care about these struggles need to increase...In a way, my views regarding the AEC profession has changed in regards to my expectations of being a minority in this profession. Through class, I have learned it is going to be way harder to navigate than I thought.”

Financial Challenges: Negative financial experiences included limited funds for materials and supplies needed for projects, especially for Architecture RPs. As noted by an Architecture RP, “Recently I have realized that I need to invest more money in the program that I’m involved in. For instance, since this coming semester involves my first Architecture course, I need to invest in the supplies necessary for my major, such as the specific pens, rulers, paper, tape, etc. that I will need. Although this hadn’t occurred to me as I first joined this program, I now know that it is necessary to invest in the supplies that I will need for this class as well as future classes I will have to take. In buying supplies like tracing paper or a certain set of Micron pens, I initially was stunned by the price, but I later made the realization that supplies like these will eventually aid my work and ideas, and in the grand scheme of things, be more beneficial than the cost.” Coping strategies included saving money, searching for scholarships, and one RP recommended universities providing material kits.

Social Challenges: The size and rigor of AEC programs resulted in isolation as few RPs found it difficult to connect with peers and keep up with their social lives. An Architecture RP explained that, “There was nothing particularly memorable. I didn’t take any classes I felt passionate about, but was swarmed with work so I didn’t hang out with friends very often.”

Psychological Challenges: Academic, physical, financial, and social challenges increased stress and caused mental health decline, particularly in Architecture RPs. RPs complained of dreading classes, being anxious, being nervous, and being afraid to ask for help. Eighty-eight percent (88%) of Architecture RPs complained about stresses from heavy workloads, financial challenges, crushing reviews, lack of sleep, lack of time, tiredness, and missing social life. An Architecture RP noted, “I had a really hard time this semester, struggling with depression and anxiety and my grades really suffered so I’m trying to better this semester by going to therapy and getting enough sleep.” While one RP considered exiting from her AEC program, most implemented coping strategies which included time management, self-care, receiving therapy, and adopting a survival mentality. In explaining her survival mentality coping strategy, an Architecture RP explained, “Since being in Architecture, I have come to confirm some of the concerns I had before my first semester. My main worry was if I would be unable to keep up with the workload of all of my classes. Further, if I would be able to manage maintaining a decent sleep schedule along with a steady income. First and foremost, I would like to interject with the modern statement “surviving” as the best means of describing the state I was in the last semester. It was a constant day by day living, seeing what was immediately due, to what could be spared for a later date. Further, this was not a concern then, but after the fact, eating habits were also impacted by just how much time one spent in the studio, at times one would go without eating because of how fast time would pass by when focusing on a single project.” While most Architecture RPs complained, few RPs noted that from previous socializers, they always knew that Architecture would be challenging. Prior understanding of AEC learning conditions is beneficial and informs the early implementation of self-regulation strategies. An Architecture RP stated that, “It’s really not as bad as everyone hyped it up to be. In my opinion, there was no need for all-nighters during the first semester, so long as you practiced good time management. I was also prepared by my high school experience. I went to an arts high school, where my major was visual arts, and the assignments and hours were very similar to those of the first-year architecture program at [Institution].”

While tolerable discomforts assured RPs that this could be the right program, overwhelming discomforts were discouraging and caused RPs to question if AEC was the right program for them. Therefore, the level of discomfort in an AEC program is an important predictor of AEC-PID.

SUB-CATEGORY 1.4: Valuing Points of Pride “THE DEAN ... TOLD ME I’M A NATURAL”

Fifty-five percent (55%) of RPs made comments related to points of pride. They addressed AEC (45%) and non-AEC (13%) achievements.

AEC Points of Pride: RPs felt good and received inspiration from achievements and recognitions related to good grades, honors, and internships. In sharing a memorable experience, an Architecture RP recollected that, “The Dean of our Architecture program told me I’m a natural at what I do.” Recognitions from AEC role models were valuable to RPs as they validated their potential for AEC success.

Non-AEC Points of Pride: RPs felt good and received inspiration from achievements and recognitions related to their non-AEC talents and passions. A Civil Engineering RP explained

that, “During the 2019 fall semester, I am proud to say that I was able to be a part of the [Concert Name] with the [Institution] Choir. We had a little under two months to learn a two-hour program of music to sing. This concert taught me not only about my ability as a singer, but power and passion an audience can feel when a choir comes together and performs amazing music. The concert brought me, and many others, to tears. I am very grateful for the opportunity and hope to soon be a part of an even greater piece of artwork.”

AEC Points of Pride increased passion for AEC professions as they assured RPs that they were in the right program. Therefore, points of pride is an important predictor of AEC-PID.

CATEGORY 2: PRIORITIZING NETWORKS

One hundred percent of RPs made statements expressing how they prioritized initiating and sustaining important connections with critical elements of AEC and non-AEC communities. Both positive and negative experiences were highlighted in the following three sub-categories that contributed the PRIORITIZING NETWORKS category:

SUB-CATEGORY 2.1: Building AEC Connections “INTERCONNECTED”

Ninety-three percent (93%) of RPs made statements related to building AEC connections. They addressed building internal institutional connections (80%) and external industry connections (50%).

Internal Institutional Connections: RPs gained knowledge and understanding of AEC theories and practices mostly from AEC professors. Effective professors increased self-efficacy and intrinsic motivation to pursue AEC through role-modeling, resources, support, and words of inspiration. A Civil Engineering RP explains, “I had never realized how broad and interconnected with the rest of the world, AEC really is. In my Intro to Civil Engineering class, one of the main things my professor did was bring in other civil engineering professors to speak to us about what they do, their research, and their lives. It was humbling to hear about the scope of research and how fascinating all the professors' lives had been, and it felt like many, many doors had been opened. I suppose that is why I was stressed about picking a focus: because there are so many incredible options. It was very interesting to learn how civil engineering has its hands in pretty much everything, and how important it really is not that I didn't think it wasn't important, it's just that a lot of the time, people don't think about the civil engineer behind every building, road, and pipe. We truly are the hidden heroes... I really want to start interacting more with my professors. Their research and knowledge of the profession is my most valuable resource and I think more than anything else, their words will matter the most as far as my obtaining a job or any other opportunities I might receive in the future. They might help me decide what I want to do with my degree, or give me access to interesting research or put me in contact with others in the profession. Plus, most of my professors have been in Civil Engineering for a long time and have so much experience, anything they could tell me would be useful as I begin to look towards the future.” Nevertheless, some RPs also complained about limited and unfavorable interactions with their professors. RPs perceived their AEC professors as important links to their AEC dreams and professions, making strong interactions with professors an important predictor of AEC-PID.

External Industry Connections: RPs interact and build connections with AEC practitioners primarily through guest lectures, internships, and student organizations. With deep desires to understand and experience realistic AEC professional roles, RPs appreciate interactions with practitioners. These interactions provided opportunities to assess career decisions, gain knowledge about resources and opportunities, heighten inspiration to persist, and model impactful strategies utilized by these role models as explained by an Environmental Engineering RP, “I have become more interested and involved in engineering since the fall semester. An environmental engineer came in and talked about all the work he does outside of the office. Environmental Engineering is my major and hearing about this made me more passionate about my major. I am excited to work outside of the office and in the outdoors... I have recently been looking for a new internship related to civil engineering. My engineering teacher from high school has helped me connect with engineers in the field and has gotten me a temporary internship during high school. I reconnected with her recently and we have been working to find me a new internship.” RPs perceive AEC practitioners as role models and are greatly inspired by them. Strong connections with AEC practitioners stir up increased passions to explore realistic and meaningful AEC professional experiences due to perceived congruence between self and AEC professionals. Positive interactions with external AEC practitioners assured RPs that they were in the right program, making positive interactions with AEC practitioners an important predictor of AEC-PID.

SUB-CATEGORY 2.2: Balancing Peer Interactions “COLLECTIVE MOTIVATION”

Eighty-eight percent (88%) of RPs made statements related to peer interactions. They included peer support (73%), peer collaboration (28%), peer competition (25%), peer discouragement (23%) and peer teaching (18%).

Peer Support: RPs valued the pleasant nature and timely assistance received from peers, especially when they were navigating difficult academic situations. Forty percent (40%) of RPs joined student organizations so that they could connect with their peers and learn more about the AEC world.

Peer Collaboration: RPs collaborated with peers on various AEC projects which were either assigned through formal academic engagement or extracurricular activities. Shared goals drove collective motivation towards collective and individual success which made learning environments effective and enjoyable. An Architecture RP explained that, “I thoroughly enjoy the environment at [Institution]. It is a place where we all learn and grow together. We use each other to bounce ideas around which benefits everyone. I appreciate our ability to collaborate through conversation and then branch off individually to personalize our design ideas.”

Peer Competition: RPs competed in local and national competitions. This was fulfilling, especially for those who were competitive in nature. Few RPs expressed appreciation that program cultures were not overwhelmingly competitive as the focus should be on learning and not just winning. An Architecture RP noted, “I was initially worried that the studio culture would be extremely competitive leading to emphasis on *winning* rather than *learning*.” Another Architecture RP emphasized, “I think the rapport between students is very healthy in that we're

all supportive of each other, and there isn't a feeling of intense competition... I've heard horror stories about students sabotaging other students' projects at schools like [US Institution].”

Peer Comparison: RPs tended to compare themselves with their peers. While comparison increased concerns in RPs, it also challenged them to implement strategies that improved performance. An Architecture RP explained that, “Architecture is not for the faint of heart, because your work does get criticized and you will question whether you are good enough when you compare yourself to those around you. I know I did, and still compare my work to the people around me, which does break me down at times. But I have been learning to see what I like I like and take influence (not copy) from others who were successful in executing their projects.”

Peer Discouragement: RPs expressed being discouraged by peers mostly through negative statements about AEC programs. Students shared negative perceptions and difficult experiences related with AEC programs, especially Architecture. These heightened concerns and stresses in RPs. An Architecture RP explained, “I was worried that I wouldn't have a life outside of architecture. Everyone warned me about architecture with its all-nighters, long hours, and crushing reviews. I was also worried that it would wreck my GPA.... There is a self-inflicted stereotype of Architecture students never being well-rested or happy with their work, and I think this is unhealthy.”

Peer Teaching: RPs benefited from teaching and learning from other students, particularly upperclassmen. Struggling RPs benefitted from excelling students who dedicated time and effort to provide them with detailed explanations which increased knowledge and understanding.

These complex and dynamic peer interactions shapes perceptions of an ideal AEC student standard. Balanced collaboration and competition is crucial to support healthy learning environments that inspires individual and collective motivation towards individual and shared goals. A Construction Management RP stated, “The environment is very lively, because of the collective motivation and encouragement that I receive from my peers and professors daily.” Balanced collaborative-competitive peer interactions should build up both independent and collective growth that support AEC-PID. Balanced interactions with peers assured RPs that they were in the right program, making it an important predictor of AEC-PID.

SUB-CATEGORY 2.3: Entertaining Non-AEC Connections “WELL-ROUNDLY”

Thirty percent (30%) of RPs made statements regarding their connections with non-AEC communities to include sororities and religious organizations. They emphasized that being exposed to non-AEC communities will support the development of a well-rounded student. A Civil Engineering RP noted, “Honestly, I feel that my program did a really nice job exposing first-year students to industry. I appreciate this considering time is of the essence and knowing what you like and what you know you do not want from a job is crucial. The only thing I wish my program did was advertise organizations not related to engineering as well, in order to develop more well-roundly. Consequently, RPs wished that AEC programs will increase student access to non-AEC resources and opportunities. Considering the rigor of AEC programs, students could also benefit from improvement in mental health if they engaged in non-AEC ventures. An Architecture RP notes, “I would say my most memorable experiences are all tied to

[Sorority Name]. Being in a sorority has provided me with lots of fun date events, fundraisers, and volunteer opportunities. It's been great for my mental health to have a life/friend group outside of architecture. My sorority friends threw me a surprise birthday party picnic on the roof of my dorm at sunset, which was one of my favorite memories from this past semester.” With increasing concerns about the emotional health of students, the proactive infusion of non-AEC resources and support systems could improve mental health and well-roundedness of students.

CATEGORY 3: SPARKING AEC-PID

One hundred percent of RPs made statements expressing important interactions that contributed to their feelings of being female AEC students and becoming female AEC professionals. Both positive and negative experiences influenced these feelings and contributed to the formation and progression of AEC-PID. They are highlighted in the following four sub-categories that contributed the SPARKING AEC-PID category:

SUB-CATEGORY 3.1: Acquiring AEC Knowledge “STUCK WITH ME”

Ninety-five percent (95%) of RPs made statements related to gaining knowledge, understanding, and competence through AEC programs. Knowledge was primarily gained through AEC lectures, labs, and other program experiences. Acquiring AEC knowledge contributed to their feelings of becoming AEC professionals. While RPs expressed an appreciation for orientation courses (18%) and strengthening soft skills (18%), majority (80%) expressed a strong desire for more realistic AEC industrial experiences. Through AEC learning, RPs gained inspiration from remote role models as expressed by an Architecture RP who stated that, “One memorable experience that really stuck with me during the Fall semester was learning about Palo Soleri through the CFA 100 class. Palo Soleri was a 19th century philosopher, architecture and designer. Palo was an Italian American architect that was interested in eco-architecture. Meaning that he felt architecture should be one with nature and that they could coexist in harmony. We learned about him through not only a discussion, but a film about him and his beliefs. He was very interesting to me because he thought outside the box. Palo wanted to create a better world where nature wouldn’t have to be disrupted because of human colonization, instead Palo believed in a more organic way of thinking.”

Acquiring knowledge contributed to AEC-PID as comparing past self to current self, RPs felt better equipped to utilize their abilities and acquired knowledge to perform future AEC roles. The acquisition of knowledge and understanding assured RPs that they were in the right program, making it a strong predictor of AEC-PID.

SUB-CATEGORY 3.2: Adjusting Views “MORE INTRIGUED”

One hundred percent (100%) of RPs made statements about their views of the AEC profession and many linked their views with their feelings of becoming female AEC professionals. With some having mixed views, RPs expressed that their views of the AEC profession had improved (60%), remained unchanged (33%), or declined (18%).

Improved Views: Despite challenges, many RPs had improved their views about AEC professions as they loved the disciplines, the impact of the industry, and the many opportunities available in AEC. Improved views improved expectancy, assurances of right career choice, and decisions to persist. An Architecture RP explained that, “My perspective of the AEC profession did change over the 2019 Fall Semester, because I was so confused about the specific major that I had chosen. At the end of my senior year, I had chosen to study Interior Architecture, simply because it had sounded more appealing to me. As I spoke to more and more people, I began to question if I chose the wrong major, because when one generally thinks of architecture, they think of the exterior of buildings, as did I. But speaking more in depth about Interior Architecture works and the process of the program at [Institution], I became more intrigued and interested in what Interior Architecture had to offer.” These RPs began to receive assurances that they had chosen the right major and career pathway. An Interior Design RP explained, “My views kind of changed, and by that I mean about myself and future profession like noticing that I had made the right decision, and that I can see myself doing this in the future.”

Unchanged Views: Notably, RPs who noted that their views had not changed were basically stating that they continued to maintain positive views of AEC professions. A Civil Engineering RP emphasized, “My previous view of the AEC profession was positive, and it has continued to stay the same over this last semester. Since my experience is limited at [Institution], it's hard to judge so far, but I am still just as excited to further my education as I was in the beginning.”

Declined views: Declining views were associated with academic struggles, lack of gender and racial diversity, and ignorance about the profession. A Dual Major noted that, “Definitely. before I started the fall semester, I was very interested in the profession of an architect rather than engineer. I wasn't very sure which is why I double majored. Through this semester, I found out that I absolutely hate architecture. I see the need for design, but I see it as second to engineering and the need for a building to be structurally sound. I hate the amount of work demanded by the architecture major. In the architecture profession, it is expected that students will ruin their mental health doing endless projects and getting little to no sleep. I saw this occur in second-fifth year students, and this doesn't change between universities. Although engineering is just as demanding, there is room for mental health and recovery and the major has been well designed for college students.”

While a few RPs made direct statements that AEC was easier than expected, some expressed that it was just ok or more difficult. Negative views discouraged the perception of fit with AEC professions, while positive (including unchanged) views assured RPs that they were in the right program. This made changes in AEC views, an important predictor of AEC-PID.

SUB-CATEGORY 3.3: Spurring Super Woman Mindset “WORK HARDER”

Twenty-five percent (25%) of RPs made comments regarding the underrepresentation of women in AEC and how it affected feelings of being female AEC students and feelings of becoming female AEC professionals. Women of color tended to express concerns with the lack of both gender and racial diversity. To minimize negative impacts, some RPs highlighted the importance of networking, advocacy, and energizing a Super Woman Mindset. In energizing her super woman mindset, a Civil Engineering RP placed emphasis on the strengths of women stating that,

“I still believe that there are many doors that have yet to be opened and I believe the key to these opportunities lie in the hands of young women, such as myself, who are eager to learn more and grow. The AEC industry is led by men. The more women the world is able to produce into this industry, the more people will see more productivity, creativity, and adaptability.” In coping with the outnumbered challenges and to self-regulate to overcome gender related challenges, a Construction Management RP noted that, “Nothing is handed to you in life and especially depending on your circumstances like myself being a minority. I have to work harder than everyone else. Drive and dedication is everything.” The Super Girl mindset involved being aware of unique challenges that women encounter in the AEC profession and being confident of women strengths and realizing that women can have significant and positive impacts on the development of AEC products and services. In addition to inner motivation, RPs tended to connect with female-focused student organizations to gain access to female AEC role models and peers who contributed to the development of the Super Woman mindset through the provision of critical resources and support. Such networks lead to women perceiving stronger connections between their female student self and their future female AEC professional self as they perceive that their unique female talents and perceptions will contribute to the development of more gender inclusive AEC products and services. Positive super woman mindsets assured RPs that they were in the right program, making it a strong predictor of AEC-PID in women.

SUB-CATEGORY 3.4: Exploring Niche “FIND A NICHE”

It is worth noting that although they were in their first-year, 25% of RPs made comments about potential niches, opportunities, and specializations. These were mostly following interactions with AEC professors and practitioners through lectures, internships, and externship experiences. An Interior Design RP stated that, “The more I learn, the more I find I don't know, and I'm excited to find a niche to work with others as a designer.” Comments and questions regarding niches and specializations suggested that RPs felt that they were in the right program and were exploring opportunities to advance in the AEC profession. This made interest in exploring AEC niche, an important predictor of AEC-PID.

In summary, changes in AEC knowledge, views, super woman mindset and exploring niche contributed to igniting and sustaining AEC-PID resulting in three categories of AEC-PID styles: Strong (82%); Medium (15%); and Weak (3%). RPs who mostly expressed improvements in their views of the AEC profession were categorized as having strong AEC-PID. RPs with a mixture of both improved and declining views were categorized as having medium AEC-PID. With mostly declining views about the AEC profession, one RP was categorized as having low AEC-PID. Despite challenges, most RPs were developing positive feelings about becoming AEC professionals.

CATEGORY 4: PROPELLING FEMALE AEC STUDENT SELF

Approximately 83% of RPs made statements linking their current female AEC student self with their future female AEC professional self. A critical question on the minds of first-year AEC women was: *Is this AEC profession a good fit for me?* One Architecture RP explained, “... I have only just started my architecture classes, but I know that it is the right profession for me and will

allow me to express myself.” Self-evaluation provides answers to this important question and drives the formation and progression of AEC-PID, which in turn drives persistence decisions.

SUB-CATEGORY 4.1: Sustaining Persistence “ANXIOUS TO BEGIN MY CAREER”

One hundred percent of RPs made statements related to their persistence in their undergraduate AEC program. Interactions between encouragement from positive learning experiences and discouragement from discomfort encountered in AEC programs shaped three persistence styles: Prevailing (92%); Hesitant (5%); and Yielding (3%).

Prevailing: With medium to strong AEC-PID, RPs were passionate and committed to their AEC programs. Their passion to persist was influenced by self-beliefs, socializers’ influence, as well as perceptions of AEC benefits and AEC industry impacts. A Civil Engineering RP who has a high math academic self-concept explained, “I saw how engineering changed people’s lives. Our guest speakers were all grateful to have chosen the engineering path. They would mention how every day is different and how often they rely on math. It makes me anxious to begin my career.” One Civil Engineering RP expressed the importance of sticking together as women to thrive and persist into male dominated AEC professions. She noted, “I would tell that person to enroll because becoming an engineer is a fun process. There are a shortage in women engineers so if they were a woman, I would tell them that we are not as common as men so we need more women engineers. Stick together and thrive together.” Progressive RPs developed strategies to enhance AEC progression through building self and building networks with focus on both AEC and non-AEC connections. With their strong AEC-PID, they expressed strong intentions to pursue internships, join student organizations, and interact with experts and peers for role-modeling and support. With strong assurances that their AEC program was a good fit for them, Progressive RPs perceived congruence between their current female AEC student self and their future female AEC professional self.

Hesitant: With medium AEC-PID, Hesitant RPs were still interested in AEC disciplines but were considering alternate pathways if they changed their minds and decided to exit from their current AEC career plan. They seemed uncertain of their long-term commitment to the AEC profession. A Civil Engineering RP explained, “Although I plan on pursuing a Civil Engineering profession, I would like to have a backup plan aligned with something in the AEC industry. I cannot yet say for sure that I will continue in this profession.” With somewhat positive assurance that this AEC program was a good fit for them, Hesitant RPs perceived limited congruence between their current female AEC self and their future female AEC professional self.

Yielding: With her low AEC-PID, this RP had exceeded her personal discomfort threshold and had decided to switch majors. This RP notes, “The system of architecture school is archaic and has made me completely detest the subject. I’m definitely switching to engineering.” Negative interactions between self and AEC learning environments resulted in declining views of the AEC program and eroded the desire to persist in the undergraduate AEC program. With the belief that the current AEC program was not a good fit, this RP perceived limited congruence between her current female AEC student self and her future female AEC professional self.

The strength of AEC-PID in RPs influenced decisions to persist, making it an important predictor of persistence in undergraduate AEC programs.

DISCUSSIONS

In frequent self-assessment, a recurring and important question asked by first year AEC women is: *Is this AEC profession a good fit for me?* The answer to this important question drives the formation and advancement of AEC-PID and influences decisions to persist in undergraduate AEC program. Their two-tiered internal self-assessment involved assessing feelings of being current female AEC students and feelings of becoming future female AEC professionals. The results of these frequent assessments impacted AEC-PID. Regardless of AEC program, race, or household income, the emerging theme, *Sparkling AEC-PID Through Agency and Networks*, highlights how interactions between self and structures contributes to the formation of AEC-PID and influences persistence in undergraduate AEC programs. This theory proposes important predictors of AEC-PID and AEC persistence in women. It captures cognitive, emotional, physical, social, and academic processes that spark AEC-PID in undergraduate AEC women.

While abilities and intrinsic motivation emerge from self, internal (institutional) and external (industrial) networks are perceived as effective channels that extrinsically motivate and connect the current female AEC student self to the future female AEC professional self. Drawing from points of pride and passion, the acquisition of knowledge through visual-kinesthetic and experiential learning experiences is satisfying and verifies career choices. While non-AEC freshman courses are enlightening, the preference is for freshman AEC courses for early exposure, sustained interest, and timely affirmation of chosen careers. The integration of non-AEC interests into learning experiences will ensure that AEC women are well-rounded, while improving emotional health. Peer collaboration and support exist alongside peer comparison and competition and inspire independent and collective motivation and growth. Positive interactions between self and AEC program environments strengthen AEC-PID because of improvement in AEC knowledge, views, mindsets, and efforts to explore niches for progression in undergraduate AEC programs and towards AEC professions. However, the lack of gender diversity remains a concern. Also, heavy workloads and unfavorable program conditions cause stress, particularly in Architecture women. These negative interactions weaken AEC-PID because it is associated with declining views about the AEC profession. Therefore, women persistence in undergraduate AEC programs requires developing the 'survival' mentality and spurring the super woman mindset. Combinations of positive and negative experiences resulted in three AEC-PID styles (Strong, Medium, and Weak). While medium to strong AEC-PID sustains the desire to persist in many *Prevailing* women, medium AEC-PID is also associated with lowered desire to persist as a few *Hesitant* women become open to other careers options. Overwhelmingly negative interactions erode AEC-PID and the desire to persist, as one *Yielding* woman plans to exit her AEC program.

This theory places emphasis on the important role of agency and networks in continually shaping pathways and developing AEC-PID in women [9][16-28].

Findings agree with theories that highlight the importance of agency in AEC-PID as women evaluate themselves and their AEC environments and make decisions to intentionally influence their own functioning and progression [35-37]. They frequently assess their own abilities, as well as the challenges and the rewards of remaining in AEC programs and pursuing AEC professions. These influence their self-concept, which is self-belief in their abilities and potential for success. Self-concept is shaped through frequent assessments involving past, current, ideal, and future self

[18][29]. An understanding of abilities and preferences influences self-concept and self-efficacy that drives expectancy to succeed in AEC programs and professions. Passion/interest, inherent abilities, significant others, benefits from industry, and desire to contribute to industry influence women's decisions to persist [9][38]. Findings agree with [9] who noted that undergraduate AEC women were creative and desired to utilize their STEM and Art strengths in future careers as they were their favorite subjects. Nevertheless, women are burdened with gender and program related challenges that make them uncomfortable in AEC learning environments. They explored strategies such as self-regulation and spurring super woman mindset to cope with challenges and persist towards AEC professions [11]. Considering that there is a gendered pathway into male-dominated AEC professions, women continuously explore coping strategies to overcome outnumbered stresses and stabilize connections between their current female AEC student self and their future female AEC professional self. [11].

Findings agree with theories that highlight the importance of socializers and socializing experiences in AEC-PID, as women engage in AEC institutional and industrial environments [38-42]. An understanding of the requirements and enhancers of AEC success guides their pursuit of resources and support to achieve AEC career goals. Internal and external AEC networks are important pathways as women observe, learn, and model successful AEC expert socializers. Positive interactions with AEC expert socializers influence knowledge acquisition, appreciation, views, and congruence with the profession. An Architecture RP explained that, "After having taken classes oriented toward architecture, there is a new level of appreciation for the craft that is planning and creating. There are so many factors that come into play when one is designing, whether it's the space available, surrounding landscape, or even the different emotions or sentiments shapes, lines, spaces, light, or other things could evoke. Now I believe that architecture is a truly powerful profession that can change the way people live or even the paths they take in their lives." Socializers also evaluate progression and encourage persistence through recognitions and rewards for success in AEC endeavors. Social comparisons involve peers and role models and contribute to perceptions of the ideal AEC student and ideal AEC professional. With the exception women who appeared stressed in architecture programs and women of color who seemed more concerned about being outnumbered in AEC learning environments, no other differentiations were observed [43]. While women value AEC academic experiences where they learn about principles and practices and make progressive decisions based on remote perceptions of future AEC professional roles, they yearn for external AEC industrial experiences because immersion in experiential learning will provide more realistic experiences that can validate decisions to persist in undergraduate AEC programs towards AEC professions.

Therefore, agency and network factors have critical impacts on undergraduate AEC women's feelings about being female AEC students and becoming female AEC professionals. Strong positive connections between self and AEC institutional and industrial structures strengthen AEC-PID as undergraduate women increase in AEC knowledge, improve AEC views, develop the super woman mindset, and explore niches. Negative connections weaken AEC-PID. The strength of AEC-PID influences perceptions of future AEC program and professional success and reinforces or weakens the desire to persist in undergraduate AEC programs towards AEC professions. In situations where self-concept, self-efficacy, and self-perceptions of rewards from current female AEC student self and future female AEC professional self are higher than tolerable challenges and stresses encountered in undergraduate AEC learning environments,

women persist [44]. Otherwise, they explore other interests and consider exiting their current AEC program. Social cognitive career theory proposes ability, self-efficacy, outcome expectations and performance as fundamental to career interest, choice, development, and persistence [38][43][45][46]. The role of socializing environments and socializers, especially female socializers, through conversations, interactions, and recognitions are extremely valuable in strengthening AEC-PID in first-year women [47-50]. This theory expands existing professional identity and career development theories focused on male-dominated STEM careers because they are mostly based on male populations with limited inclusion of experiences and perceptions of undergraduate women. Furthermore, it provides empirical evidence to inform the development of future research to gain deeper insights into women underrepresentation in undergraduate AEC programs and professions.

Findings from this research inform policies and practices to advance women participation in undergraduate AEC programs. Critical resources should be provided to support women in AEC programs. Also, there is the strong need for women to self-motivate and self-regulate in pursuit of those critical resources and support that will help them overcome challenges in the male-dominated AEC learning environment and persist towards becoming AEC professionals as AEC-PID matures. Critical self-regulation strategies include time management, seeking for assistance, self-care, developing the ‘survival’ mentality, and spurring super women mindset [34]. Considering that RPs were in the first year of AEC programs, they seemed most concerned about their ‘fit’ with their respective AEC programs. Freshmen need specific AEC learning experiences that will assure them that they made the right career decision. This is critical for early exposure, sustained interest, and timely affirmation of chosen careers. AEC educators should proactively address these ‘fit’ questions and concerns by implementing early curricular and extracurricular engagements that will connect women to AEC professional roles and provide much needed assurances. These engagements could include offering gateway AEC courses in the freshman year, having female AEC professors, providing access to female AEC professionals (role models), incorporating AEC project case studies with women as AEC professionals, hosting guest lecturers, sharing professors’ research projects, supporting peer and upperclassmen engagements, enriching AEC student organization events, and providing opportunities for internships and externships. Departmental career fairs will enhance access to early internships, particularly for freshmen. AEC professors and administrators should provide kinesthetic learning opportunities in balanced collaborative-competitive learning environments that will enhance learning rather than promote rivalry and limit desires to share AEC knowledge and experiences. Considering stressful encounters narrated by Architecture students, modifications to Architecture programs and additional resources and support for academic progression and mental health will be valuable to students. Gender inclusive learning environments should utilize innovative strategies to reduce outnumbered stresses and increase female engagement in learning environments. Female-focused student organizations will provide nurturing spaces with access to female role models to enhance connections between female student self and female professional self. Lastly, the inclusion of non-AEC resources and support towards a more well-rounded female AEC student may be beneficial in improving emotional health, as well as educational and professional outcomes. The maintenance of gender inclusive AEC academic, institutional, and industrial environments will strengthen AEC-PID in undergraduate women. In turn, strong AEC-PID will strengthen persistence in AEC programs and towards AEC professions.

CONCLUSION & FUTURE WORK

Rather than broad theories related to general STEM professional identity development in undergraduate students, the uniqueness of this research lies in its gender and AEC industry contexts which expand existing theories to include the perceptions and experiences of first-year AEC women. The theory captures cognitive, emotional, physical, social, and academic processes that are involved in the formation and progression AEC-PID in first-year women. It proposes important predictors of AEC-PID and persistence in women. It is critical that undergraduate AEC women are provided early AEC gateway experiences that assure them that they are in the right program. It has theoretical and practical implications for AEC education and research supporting PID processes in AEC women. Beyond contributing to reductions in AEC workforce shortages, insights can inform policies and practices that support the attraction and preparation of talented women for a more gender inclusive AEC workforce for enhanced innovative and gender-friendly AEC products and services. With caution, some findings may inform theories and practices in other male-dominant STEM programs and professions. Ongoing research is focused on exploring AEC-PID processes in upperclassmen.

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REFERENCES

- [1] J. O. Choi, P. P. Shrestha, J. Lim, and B. K. Shrestha, "An investigation of construction workforce inequalities and biases in the Architecture, Engineering, and Construction (AEC) Industry," Construction Research Congress 2018, 2018.
- [2] United States Department of Labor, "Industry at a glance," 2022. [Online]. Available: <https://www.bls.gov/iag/tgs/iag23.htm> [Accessed February 14, 2022]
- [3] GCA International, "The talent shortage: Will the training the AEC industry desperately needs arrive in time?" 2020. [Online]. Available: <https://gcaintl.wordpress.com/2020/11/03/the-talent-shortage-will-the-training-the-aec-industry-desperately-needs-arrive-in-time-a-e-executive-search-gca-international/> [Accessed February 14, 2022]
- [4] Associated General Contractors of America, "Construction Workforce Shortages Reach Pre-pandemic Levels Even as Coronavirus Continues to Impact Projects & Disrupt Supply Chains," 2021. [Online]. Available: <https://www.agc.org/news/2021/09/02/construction-workforce-shortages-reach-pre-pandemic-levels-even-coronavirus> [Accessed February 14, 2022]
- [5] McKinsey & Company, "Women in the Workplace – 2021," 2021. [Online]. Available: Retrieved from <https://www.mckinsey.com/featured-insights/diversity-and-inclusion/women-in-the-workplace> [Accessed February 14, 2022]

- [6] United Nations Educational, Scientific and Cultural Organization, “Cracking the code: Girls’ and women’s education in science, technology, engineering, and mathematics (STEM),” Education 2030. 2017. [Online]. Available: <https://unesdoc.unesco.org/ark:/48223/pf0000253479> [Accessed February 14, 2022]
- [7] National Association of Women in Construction (2022), “Statistics of Women in Construction,” 2022. [Online]. Available: <https://www.nawic.org/nawic/Statistics.asp#:~:text=Statistics%20%2D%20NAWIC&text=Women%20working%20in%20construction%20numbered,entire%20U.S.%20workforce%20in%202018.&text=Women%20in%20the%20U.S.%20earn,percent%20of%20what%20men%20make>. [Accessed February 14, 2022]
- [8] A. N. Ofori-Boadu, “Assessment of scientific literacy skills and attitudes of undergraduate construction management students,” Proceedings of the 2018 American Society for Engineering Education (ASEE) conference, Salt Lake City, Utah, USA, June 24 – 27, 2018, 2018a, pp. 1 - 11.
- [9] A. N. Ofori-Boadu, *Improving Middle-School Girls’ Self- Efficacy, Interests, and Knowledge in ‘Sustainable Construction Engineering’ through a STEAM ACTIVATED! Program*, Proceedings of the 2018 American Society for Engineering Education (ASEE) conference, Salt Lake City, Utah, USA, June 24 – 27, 2018, 2018b, pp. 1 - 21.
- [10] D. Porter and A. N. Ofori-Boadu, *Examination of future construction career role preferences and identities of construction students*, Proceedings of the 2018 American Society for Engineering Education (ASEE) conference, Salt Lake City, Utah, USA, June 24 – 27, 2018, 2018, pp. 1 - 15.
- [11] A. Phipps, *Engineering Women: The ‘Gendering’ of professional identities*, Int. J. Eng. Ed., vol. 18, no. 4, pp. 409-414, June 2002.
- [12] A. N. Ofori-Boadu, V. Ofori-Boadu, I. Borders-Taylor, L. Waller, and P. Akangah, *Professional Identity Formation and Development in HBCU Construction*, Proceedings of the 2019 American Society for Engineering Education (ASEE) conference, Tampa, Florida, USA, June 16 – 19, 2019, pp. 1-16.
- [13] A. N. Ofori-Boadu, D. Deng, C. Stevens, K. Gore, and I. Borders-Taylor, *Learning Experiences and Self-efficacy of Minority Middle-School Girls during a ‘Bio-char Modified Cement Paste’ Research Program at an HBCU*, Proceedings of the 2019 American Society for Engineering Education (ASEE) conference, Tampa, Florida, USA, June 16 – 19, 2019, pp. 1-16.
- [14] A. N. Ofori-Boadu, R. B. Pyle, I. Borders-Taylor, C. Bock-Hyeng, and T. Graham, *Advancing HBCU Students’ Interests in Residential Construction Careers through an NAHB program: An Industry-University Collaboration*, Proceedings of the 2019 American Society for Engineering Education (ASEE) conference, Tampa, Florida, USA, June 16 – 19, 2019, 2019, pp. 1-17.
- [15] A. N. Ofori-Boadu, M. A. Shofoluwe, R. Kelley, E. R. Sowells, and R. B. Pyle, *Assessing the impact of an industry-led professional development workshop on the 21st century ‘soft’ skills of CM students at an HBCU*, Proceedings of the 2017 American Society for Engineering Education (ASEE) conference, Columbus, Ohio, USA, June 25 – 28, 2017, 2017, pp. 1 - 17.
- [16] P. J. Burke and J. E. Stets, *Identity Theory*. New York, New York: Oxford University Press, Inc., 2009.

- [17] A.N. Ofori-Boadu, V. Ofori-Boadu, J. Vanderpool, & D. Deng (2020), *Nascent Professional Identity Development in Freshman Architecture, Engineering, and Construction Women*, Proceedings of the 2020 Virtual American Society for Engineering Education (ASEE) conference. (June 21- 24, 2020), pp. 1 – 16, 2020.
- [18] Cruess, R.L., Cruess, S.R., Boudreau, J.D., Snell, L., & Steinert, Y., “Reframing medical education to support professional identity formation,” *Acad. Med.*, vol. 89, pp. 1446–1451, 2014.
- [19] D. Beijaard, P.C. Meijer, and N. Verloop, “Reconsidering research on teachers’ professional identity,” *Teaching and Teacher Education*, vol. 20, pp. 107 – 128, Feb. 2004.
- [20] M. Kogan, “Higher education communities and academic identity,” *Higher Education Quarterly*, vol. 54, no. 3, pp. 207 – 216, Dec 2000.
- [21] A. Kerby, *Narrative and self*. Bloomington, IN: Indiana University Press, 1991.
- [22] B. M. Capobianco, “Undergraduate women engineering their professional identities,” *Journal of Women and Minorities in Science and Engineering*, vol. 12, no. 2-3, pp. 95 – 117, Jan. 2006.
- [23] J. P. Gee, “Identity as an Analytic Lens for Research in Education,” *Review in Research in Education*, vol. 25, pp. 99 – 125, 2000.
- [24] J. Helms, “Science and me: Subject matter and identity in secondary science teachers,” *Journal of Research in Science Teaching*, vol. 35, no. 7, pp. 811 – 834, Dec. 1998.
- [25] D., Holland, W., Lachiotte, D., Skinner, and C. Cain, *Identity and agency in cultural worlds*, Cambridge, MA: Harvard University Press. 1998.
- [26] L. Kohlberg, *The Psychology of Moral Development: The Nature and Validity of Moral Stages*. San Francisco, CA: Harper & Row, 1984.
- [27] R. Kegan, *The Evolving Self: Problem and Process in Human Development*. Cambridge, MA: Harvard University Press, 1982.
- [28] J. Piaget and B. Inhelder, *The Psychology of the Child*, New York, NY: Basic Books. 1969.
- [29] V. L. Vignoles, S.J. Schwartz, and K. Luyckx, “Toward an integrative view of identity,” In: Schwartz, S.J., Luyckx, K., & Vignoles, V.L., eds. *Handbook of Identity Theory and Research*. New York, NY: Springer. 2011.
- [30] D. M. Hatmaker, “Engineering Identity: Gender and professional identity negotiation among women engineers,” *Gender, Work and Organization*, vol. 20, no. 4, pp. 382 - 396, July 2013.
- [31] C. Groen, D. R. Simmons, and L. D. McNair, *An introduction to grounded theory: Choosing and implementing an emergent method*, 2017 ASEE Annual Conference & Exposition, Columbus, Ohio, June 24 – 28, 2017. pp. 1-18.
- [32] K. Charmaz, *Constructing grounded theory: A practical guide through qualitative analysis*. California, US: Sage Publications, 2006.
- [33] G. Alemu, B. Stevens, P. Ross, P., & J. Chandler. The use of a constructivist grounded theory method to explore the role of socially-constructed metadata (web 2.0) approaches, *Qualitative and Quantitative Methods in Libraries*, vol. 4, pp. 517 – 540, 2015.
- [34] Bandura, A. (1991). *Social Cognitive Theory of Self-Regulation, Organizational Behavior and Human Decision Processes*, 50, 248 – 287.

- [35] Bandura, A. (2001). Social Cognitive Theory: An Agentic Perspective,” *Annu. Rev. Psychol.*, 52 (1), 1–26.
- [36] Bandura, A. (1989). Human agency in social cognitive theory, *Am. Psychol.*, 44(9), 1175–1184.
- [37] Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.
- [38] Eccles J. S. and Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation, *Contemporary Educational Psychology*, 61, 1 - 61 DOI: <https://doi.org/10.1016/j.cedpsych.2020.101859>.
- [39] Cahill, M. & Furey, E. (2017). The early years: career development for young children. A Guide for Educators. Toronto: CERIC Foundation House. Retrieved from <https://cica.org.au/wp-content/uploads/The-Early-Years-Career-Development-for-Young-Children-Educators-Guide-October-2017.pdf>
- [40] Shavelson, R. J., Hubner, J. J., & Stanton, G. C. (1976). Validation of construct interpretations. *Review of Educational Research*, 46, 407 – 441.
- [41] D. E. Super, (1953). A theory of vocational development. *American Psychologist*, 8(5), 185–190. <https://doi.org/10.1037/h0056046>
- [42] D. E. Super, (1963), Self-concepts in vocational development. In D. E. Super (Ed.), *Career development: Self-Concept Theory* (pp. 1-16). New York: College Entrance Examination Board.
- [43] Blosser, E. (2020). An examination of Black women’s experiences in undergraduate engineering on a primarily white campus: Considering institutional strategies for change. *Journal of Engineering Education*, 109, 52 – 71.
- [44] Marcia, J. E. (2010). Life transitions and stress in the context of psychosocial development. In T. W. Miller (Ed.), *Handbook of stressful transitions across the lifespan* (pp. 19–34). Springer Science + Business Media. https://doi.org/10.1007/978-1-4419-0748-6_2
- [45] Lent, R. W., & Brown, S. D. (2002). Social cognitive career theory and adult career development. In S. G. Niles (Ed.), *Adult Career Development: Concepts, issues and practices* (pp. 76–97). National Career Development Association.
- [46] McCall, C., McNair, L., & Simmons, D. (2021). Advancing from outsider to insider: A grounded theory of professional identity negotiation in undergraduate engineering. *Journal of Engineering Education*, 110, 393 -413.
- [47] Lazarides, R., Rubach, C., and Ittel, A. (2017). Adolescents’ perceptions of socializers’ beliefs, career-related conversations and motivation in mathematics, *Dev Psychology*, 53(3), 525-539.
- [48] Carlone, H. B. & Johnson, A. (2007). Understanding the science experiences of successful women of color: science identity as an analytical lens. *Journal of Research in Science Learning*, 44(2), 1187 – 1218.
- [49] H.B. Carlone, “The cultural production of science in reform-based physics: Girls’ access, participation, and resistance,” *Journal of Research in Science and Teaching*, vol. 41, no. 4, pp. 392 – 414, March 2004.
- [50] N. Brickhouse, “Embodying science: A feminist perspective on learning,” *Journal of Research in Science Teaching*, vol. 38, no. 3, pp. 282-295, Mar. 2001. N. Brickhouse, K. Lowery, and K. Schultz. “What kind of girl does science? The construction of school

science identities,” *Journal of Research in Science Teaching*, vol. 37, no. 5, pp. 441-458, April 2000.