

## **Exploring the Influence of Identity Development on Public Policy Career Pathways for Engineers**

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## **Abstract**

With emerging technologies getting in the hands of the public at ever-increasing speeds, technology policymaking has become the primary means of regulating it. This means more individuals capable of understanding their nuances and conveying the information to the masses are required. Ethical governance of these advancements is best achieved when informed by ethically motivated technology experts, including engineers, as injecting ethics into the formation of policy begins with those who write it. For these reasons, it would be valuable to understand the relationship between the variables that may influence a technology expert in their pursuance of a policy career path, such as the development of their various identities (personal and social, engineering, and ethical identities) of these engineers. Discussions have taken place regarding public policy engineering workforce expectations and development and the use of these various identities, particularly ethics identity, in establishing a policy career pathway for engineers. There is not an explicit connection between the influence of these identities, whether personal and social, engineering, or ethical, on the establishment of public policy as a career pathway for engineers. In this theory paper, we aim to explore (1) what theoretical constructs are most prevalent among several theories for each form of identity development (personal and social, engineering, and ethical), and (2) whether these various identities have the potential to be leveraged in the establishment of a policy career pathway. We review the existing literature on the identity of engineers (including personal and social, engineering, and ethical) and consider the relation between these identities and public policy as a career for engineers. To complement the literature review, we provide examples from interviews conducted with technology experts who participate in AI ethics-related policymaking to illustrate how identity may influence one's journey in cultivating policy career. These interviews underwent thematic coding as part of a larger study, and during this process, participants unexpectedly referenced identity-based experiences which influenced them. This specifically refers to experiences the individuals had in which their perceptions of their experiences were shaped by constructs of their personal and social identity, engineering identity, or ethical identity. A review of literature pertaining personal and social, engineering, and ethical identity development provides the necessary context to further establish the connection between them and their presence in the public policy career pathway for engineers. This paper will guide future research which requires a basis in the explicit relationship among various theoretical constructs of personal and social, engineering, and ethical identities development and the public policy career pathway for engineers.

## **Introduction**

All engineers were, at one point, engineering students who were naïve to the breadth and depth of the field. Uncertain of who they were and unaware of even the most salient career paths, they began their developmental journeys to determine their who they are, what they value, and where they want to go. In higher education, where engineering students are building not only the foundation of their knowledge but forming their various identities and establishing their careers as well, it is a valuable timeframe to investigate [1] [2] [3]. During this period, we can better understand how engineering students' personal and social identities, which are their conceptions

of themselves as individuals and group members, engineering identities, which is their conceptions of themselves as engineers, and ethical identities, which is their conception of themselves as people who identify with their professional ethics, develop. Reviewing these three identity types is valuable in identifying both their pre-established impacts on career choice and aspirations as well as the remaining gaps in literature that need to be filled such as the connection between moral behavior and vocational choice [3] [4] [5].

With the understanding that the above forms of identity influence career choice, we can leverage constructs of these forms of identity development to establish particular career paths. In this paper, we will focus on public policy as a career for engineers. Developing this distinct career pathway would be fulfilling an established need for engineers in public policy as current work in the area has been limited to identifying the gap and identifying skills engineers need to navigate policy [6]. Specifically, the area of public policy responsible for regulating the development and application of emerging technologies could benefit from the expertise of engineers both in the areas of technical knowledge and engineering ethics. This aligns with Craps et al. [7]'s optimization and customization roles for early career engineers, two of the three possible roles a young engineering career can fulfill. In the combination of these two roles, engineers are technical experts who advance and optimize technology processes to meet the needs of customers, or in the case of policy, the public. Following this framework, a career for recent engineering graduates in technology public policy utilizes their skills in continuous improvement and mediation of resources, disciplines, and goals. Overall, the presence of engineers in the technology policy writing process has the potential to create more accurately informed technology policy. Additionally, ethically trained engineers are believed to be able to implement ethical standards specific to their field into the policy to ensure the policy can guide responsible development and use of emerging technologies.

The establishment of a public policy career pathway for engineers potentially lies in finding the common themes of personal and social identity, engineering identity, and ethical identity development and demonstrating how the commonalities can be leveraged to directly lead to a public policy career. Currently, there is little literature available in the areas of public policy engineering workforce expectations and development and the use of these various identities, particularly ethics identity, in establishing a policy career pathway for engineers. Pertaining to public policy workforce development, currently, there is limited work on the skills, such as technical skills or risk management skills, required for and the expectations of engineers who work in public policy [6] [8] [9]. Work has also been done to understand the connection between personal, social, and moral identity and behavior in public policy career; how individuals define their policy interests stems from how they have constructed who they are (their identities) relative to others in the same system [10].

Despite these areas of work, there remains the need to establish a career pathway for engineering students to public policy. Given the presented gap in literature and the potential benefits of engineers' involvement in the technology policy writing process, the question this paper ponders is as follows: how can the personal and social identity, professional engineering identity, and ethical identity development of engineering students be related to their pursuance of a career in public policy?

The paper proceeds as follows. The bulk of this paper is a literature review covering three areas of identity development in engineering education: (1) personal and social identity development, (2) professional engineering identity development, and (3) ethical identity development. Pertaining to personal and social identity development, the review covers works which emphasize the interplay of personal and social identity development to determine what constructs both identity types require in order to develop. Works on both personal and social identity development are valuable as personal and social identity discuss both the sense of self and values that can influence one's lifelong passions that may potentially turn into a career. Pertaining to engineering identity development, this is relevant to the discussion as it establishes the factors that influence commitment to the field of engineering; perhaps these can then be examined in the light of application of engineering expertise to a public policy career.

Finally, pertaining to ethical identity development, literature was not readily available for review. To circumvent this, we pulled literature from moral identity development and current engineering ethics education interventions. Moral identity development demonstrates how an individual's morality is related to their sense of self. Engineering ethics interventions provide insight into the established engineering ethics, what the current goals of engineering ethics education are, and how they are currently being instilled in students. Together, a picture is painted of how engineering students may begin to develop an ethical identity: how the profession's established ethics relates to their sense of self.

In the discussion, we will pull together and compare the literature to identify the common constructs of each as an attempt to address the question this paper presents. The response this paper offers to the research question is a discussion on how understanding the more prevalent theoretical constructs among each of the various forms of identity development will be beneficial in establishing a distinct policy career pathway for engineers. We will identify the most prevalent theoretical constructs amongst the theories in each section and then describe how these theoretical constructs can be potentially leveraged to establish a clearer career pathway to public policy. Additionally, comments participants made during interviews (as part of a larger study) pertaining to their various identities will be included as examples of how the prevalent identity constructs discovered in this paper emerge in the career paths of individuals working as technology experts in public policy. The discussion will then be rounded out in by acknowledging the limitations of work.

## **Literature Review**

This literature review aims to understand the constructs of each theory included in order to later determine which, if any, constructs are common between each form of identity development (personal and social, engineering, and ethical). For this reason, we aimed to include foundational theories rather than more recent theories which often built off or adapted the former. For instance, when reviewing potential theories for engineering identity development, work by Patrick and Borrego [11] collected and reviewed literature on the topic and provided observations on the identity theories cited within each. This made apparent various, more recent theories that build off a smaller pool of foundational works. Examples from this paper [11] of more recent works who cited the same classic theory include those by Matusovich et al. [36], Fleming et al. [37] and Carlone and Johnson [38] all reference Gee [20]. While these works offer

valuable insights into the applications and adaptations of science and engineering identity in varying institutional, racial, and gender contexts, this paper aims to identify commonalities that may be more readily identified by looking at their theoretical foundation rather than their adaptations. It was decided that including more recent theories would not necessarily provide better insight into the common constructs among theories than the foundational works many of them referenced would.

### *Personal and Social Identity Development in Engineering*

The term “identity” is understood generally as personhood (one’s values, beliefs, goals, associations, etc.), but within social science research, two forms of identity development theory have been established and referenced: (1) personal identity development which is self-identification “composed of the meanings that persons attach to the multiple roles they typically play” (e.g., student, engineer, music-buff, football fan) and (2) social identity development which is categorization based on interactions within interpersonal dynamics and social contexts (e.g., race, gender, culture) [12, pp. 284]. These two avenues of identity development are relevant to this work as they have both been prominently featured in engineering education research pertaining to identity. While these works have established the differences between personal and social identity; they have also demonstrated to be, in many ways, intertwined leading to their both being addressed in this section [13] [14]. In this section, three works which directly or indirectly discuss the interplay between personal and social identity development are introduced.

The first example of a theory that addresses both personal and social identity development is Social Identity Theory. This theory was established by Tajfel and Turner [14], and it differentiates between how people develop their sense of self as an individual (personal identity) and as part of a group (social identity). According to the theory, personal identity is developed from self-knowledge of personal attributes which then leads to an individual’s association with groups; here, personal and social identity exist on a continuum. Three psychological processes culminate in the development of a social identity: (1) social categorization which is the perception of oneself as part of a group, (2) social identification which is the sense of self formed in relation to how one view others, and (3) social comparison which is one’s relative social value [14] [15]

These processes stem from three general assumptions: (1) individual’s desire a positive self-concept and self-esteem, (2) social categories and membership of them convey either positive or negative value, and (3) the determination of one’s own group value is relative to the perceived value of other groups [16]. Based on these assumptions and constructs, the aim of an individual is to create a positive social image, and this goal can be threatened by a perceived lack of competence, questionable moral behavior, or even when an individual or group feels they are not recognized as a person or group with autonomy or unique qualities [17]. This would in turn cause one’s social identity to develop in a negative direction; development in a positive direction would occur when one’s social identification and social comparison reflected good or popular behaviors or attitudes either through initiating positive change in their group or potentially moving to another group that aligns with their developed personal identity.

The second theory which differentiates and acknowledges the interplay between personal and social identity development is Turner et al.'s [14] Self-Categorization Theory. This theory explicitly notes that, depending on a situation's relative value to a person, one or both identity types will influence the person's behavior. This is also the reigning difference between Tajfel's [14] Social Identity Theory and Turner's [18] Self-Categorization Theory; where the former "suggests a continuum of interpersonal versus intergroup behavior," the latter "pronounces that both—social and personal identity processes—may be at work simultaneously" [15]. Self-Categorization notes that personal identity is the self-descriptions pertaining to one's personal attributes and social identity is the self-descriptions pertaining to one's membership of a group.

There are four processes that an individual goes through to develop these identities: (1) self-categorization, (2) salience, (3) depersonalization, and (4) individuality. *Self-categorization* can be viewed through the concept of abstraction of which there are innumerable categories a person can align with based on the interplay between personal values, belief, and attributes and the social context they are in. The general levels of abstraction note that the lower levels reflect the personal categories, and the higher levels reflect more social categories. *Salience* refers to the prominence of a particular category in a given situation. One moment, circumstances may call for an individual to rely more on their personal categories than their social categories; the next moment may require the opposite or for equal consideration to both personal and social categories. *Depersonalization* is the over-identification with a group where one's self-categorization essentially becomes a stereotype; this self-stereotyping "indicates that self-perception is dominated by social identity" and "thus turns individual behavior into collective behavior" [15, pp. 7]. *Individuality* conveys that social comparison is the means of avoiding depersonalization as it indicates that "a behavior or self-perception is determined by personal identity" rather than a group identity [15, pp. 7] [19]. These four processes are in continuous flux meaning that the self is in constant development.

Our third example of a theory that touches on both personal and social identity development is Gee's [20] Identity Theory which states that there are four dimensions of identity: (1) nature-, (2) institution-, (3) discourse-, and (4) affinity-identity. *Nature-identity* is the identity you are born with that is generally unchangeable and category-based like race, gender, or culture; an individual develops a sense of personhood due to the social or cultural meanings attached to them. *Institution-identity* is an identity that is imparted on an individual by a prominent power in that institution based on their participation in the system such as being awarded a doctorate by a university. *Discourse-identity* is identity imparted on an individual based on the way they present themselves such as personality traits or how they speak, act, or interact. Finally, an *affinity-identity* is formed through affiliation with a group based on personal interests, values, and beliefs such as joining a club or church.

While not explicitly stated in the theory, based on our previous discussion, we can see how both social identity and personal identity are present in this theory. For nature-identity, the force is established "because they are recognized" by oneself and others through the lens of "institutions, discourse and dialogue, or affinity groups, that is, the very forces that constitute our other perspectives on identity" [20, pp. 102]. Nature- differs from discourse-identity in which individuals are solely subject to the social perceptions and categorizations of others; "the 'power' [...] is the discourse or dialogue of other people" [20, pp. 103]. Similarly, with institution-

identity being something that is imparted on an individual who meets criteria set, there is more of a reliance on social perceptions. Affinity-identity sticks out as the construct which relies more so on personal perceptions as one chooses to engage in practices that in turn make them a type of person. All four constructs combine and influence one's sense of personhood; each construct relies on either or both personal and social perceptions for development.

### *Professional Engineering Identity in Engineering*

In this section, we will discuss three works on professional engineering identity development; professional engineering identity refers to the specific type of engineering identity that is established in works which cover the connection between engineering identity and pursuance of an engineering career. The global need for engineers has bolstered the desire to better understand why and how people are drawn to an engineering career. Engineering identity is one factor that influences a student's choice to pursue an engineering career; a student's identity as an engineer can affect their "academic and personal development, retention, and incorporation into the larger engineering community" [21]. In engineering education, there have been numerous attempts at understanding engineering identity which commonly focuses on one's sense of belongingness and commitment to their engineering program which is often indicative of their desire to pursue an engineering career.

Our first work pertaining to engineering identity is Godwin's [21] instrument to measure students engineering identity development; the three constructs of identity that were applied to this instrument include (1) interest in engineering, (2) recognition as a person who does engineering, and (3) performance/competence (doing well/understanding) in engineering. The instrument includes statements such as "I enjoy engineering" and "I find fulfillment in doing engineering" as measures for interest, "my parents" or "my instructors see me as an engineer" as a measure for recognition, and "I can do well on exams in engineering" or "I can overcome setbacks in engineering" as measures for performance/competence [21, pp. 8]. The inclusion of statements regarding students' perceived role as "an engineer" rather than specifying their status as a student demonstrates and emphasizes Godwin's reference to works which show engineering identity to be a "significant indicator" of professional persistence [21, pp. 2].

By measuring these constructs, we can better understand where support can be offered to better develop engineering identity in students which can lead to an increase in retention of students in engineering programs and integration into the engineering profession. Development of engineering identity occurs when students negotiate their roles among their peers, faculty, mentors, and the community of engineers at large. Godwin states that engineering students "must author individual identities that map to the group identity of an engineer" where group identity refers to the shared belongingness to the role, category, or group of "engineers" [21, pp. 3]. This means development of the above constructs is achieved through active participation and recognition in the engineering social sphere.

Our second example of a theory of engineering identity is by Jones et al. [22]. This work applied Domain Identification Theory, defined as "the extent to which students define themselves through a role or performance in activities related to the domain," to the realm of engineering [22, pp. 1342]. There are three constructs influencing engineering identity: (1) engineering utility

which is one's perceived value of the information towards future goals, (2) engineering program belongingness which is one's sense of connection to the engineering group, and (3) program expectancy which is how well one expects to perform the engineering work. These constructs of identity are developed by "[students'] continued perceptions of engineering-related courses, motivational beliefs, choices and effort, and academic outcomes" [22, pp. 1342].

The results of this work show that a student's level of development of their engineering identity was a significant predictor of whether students intended to persist into an engineering career. Jones et al. offers the example of a student who feels recognized in their engineering program but does not pursue a career in engineering because the work does not correlate with their sense of self; this could result from high program expectancy and influence an increase in program belongingness but a low sense of engineering utility. All of this suggests that "careful attention to factors that affect career intentions," utility, belongingness, and expectancy, should be paid when facilitating the development of engineering identity in students as these constructs each have demonstrated themselves to be predictors of engineering career intentions [22, pp. 1352].

Our third example of engineering identity development as applied to pursuance of an engineering career pertains to engineering identity development for women. Capobianco et al. [23] notes the uniqueness and importance of the formation of engineering identities in women; this study offers four constructs of engineering identity development: (1) academic which is self-belief as engineering students, (2) institutional which is affiliation or attachment to their program, (3) gendered which establishes who they are as women and the mediation of their gender in their program, and (4) role models which emphasizes having aspirations and receiving support. According to participants, persistence seemed to be a major key to development in these constructs.

Links between academic and institutional identities were observed in the form of how women described themselves as students and their commitment to their program. A link between gendered and role model identities were also found in statements provided by participants in which all participants described how other women (such as relatives, professors, or professionals) inspired certain decisions, actions, and developments in their programs. A specific example of this included receiving advice on how to navigate instances of gender bias or discrimination in male-dominated engineering spaces. Experiences like these could potentially make or break one's commitment to pursuing an engineering career and are potential obstacles for women in engineering particularly.

### *Ethical Identity in Engineering*

In this section, we will discuss the present work available relevant to the concept of ethical identity development in engineering. Current discussion on engineering ethics education has focused on what ethical work, choices, and behaviors look like in the field, but has only indirectly discussed the importance of instilling an ethical identity in engineering students. Due to a lack of work available on ethical identity in engineering, two philosophical and psychological works pertaining to moral identity development as well as one literature review on current engineering ethics education interventions was reviewed to begin addressing the gap between the moral identity development and ethical expectations of engineers.



We will begin with the available work on moral identity development which is a field that emerged from preceding works pertaining to moral motivation and moral emotion. As commonly understood, morals pertain to independent values, so moral identity “generally refers to the degree to which being a moral person is important to an individual’s identity” [24, pp. 213]. Ethics pertains to the collective values held by a group or profession; following the same structure, this would mean that an ethical identity in engineering refers to the degree to which an engineer identifies with the ethical code they work within.

Work pertaining to morality has historically revolved around moral reasoning, such as Kohlberg’s [25] [26] Theory of Moral Development, or moral emotion, such as Hoffman’s (2001) Theory of Empathy and Moral Development. Kohlberg’s [25] [26] Theory discusses the six stages of moral development an individual can potentially move through from obedience and punishment (be obedient only to avoid punishment) to (6) universal ethical principles (sense of justice is more important than law). With the stages being associated with age, Kohlberg’s Theory assess the moral reasoning applied by individuals at these varying developmental stages and how they increasingly consider the viewpoints of those around them when confronted moral dilemmas they are ill-equipped to solve. Hoffman’s [27] Theory of Empathy and Moral Development works around Hoffman’s accepted definition of empathy as “the involvement of psychological processes that make a person have feelings that are more congruent with another’s situation than his own situation” [27, pp. 30]. This theory offers the idea that one’s empathetic distress combats any egoistic motives one has which can encourage moral development due to the connection between empathetic distress and helping.

The first example of moral identity development we will cover comes from Blasi [28]. Contrary to these theories which focused on moral reasoning and emotion, Blasi theorized that identity was the missing component in the common belief of why individuals performed moral actions. This moral identity development contains three constructs: (1) judgement of responsibility where an individual determines whether an action is both moral and necessary, (2) moral identity which reflects how important being moral is to their sense of self, and (3) self-consistency which is the proclivity of humans to act in a manner consistent with how they view themselves. The Self Model of Moral Action states that moral action comes when a moral judgement is made and reflected on in relation to an individual’s personal identity. An individual’s moral commitments to themselves is the deciding factor of one’s action or inaction as “moral commitments that are core, deep, and essential to our self-understanding [contribute] to our sense of personal integrity-in-action” [28] [29, pp. 242]. The inclusion of identity in the discussion of morality allows for associated constructs of identity like values and goals to be introduced which in turn establish moral commitments; moral commitments are made and kept due to the human inclination for self-consistency which aids in being able to identify oneself.

The second example of moral identity development comes from Colby and Damon [30] who emphasized the importance of *being* moral rather than *acting* moral. Specifically, Colby and Damon [30] state that when one has “certainty,” “positivity,” and “unity of self and moral goals” it means that prioritizing moral action is not a burden, rather it becomes a way of life that a person takes on [29, pp. 361]. Developing this unity stems from experiences with social contexts that then shift an individual’s lifelong moral commitments. As this moral development is the

convergence of personal and moral goals, moral identity development is a gradual process with bouts of development being triggered by major personal life events. Consider an individual who is diagnosed with, then overcomes, breast cancer and chooses to devote their lives to breast cancer awareness and charitable work in that area. The traumatic experience of being diagnosed with breast cancer has caused a shift in personal goal (i.e., to overcome breast cancer) which, through reflection and social influence, creates certainty and positivity that ultimately aligns with a strong moral goal (i.e., raise awareness and help others overcome breast cancer).

Having now reviewed two examples of moral identity development, we will move on to a review of recent engineering ethics interventions to better understand the current landscape of engineering ethics education. Hess and Fore [31] systematically reviewed a series of works which featured ethics interventions in engineering education to create an overview of the ways engineering students are being introduced to ethics. Each of the twenty-six reviewed articles stated establishing skills pertaining to ethical sensitivity/awareness, ethical judgement/decision-making/imagination, and ethical courage/confidence/commitment as learning goals. These goals demonstrate that there is a desire to establish an ethical sensibility in students that goes beyond simply following rules as to avoid punishment. The means of developing these ethical characteristics in students were pedagogical techniques. The review found that the most common methods for integrating ethics into student courses were exposing students to codes/standards in 85% of the articles, utilizing case studies in course work in 81%, and providing opportunity for discussion activities in 77%, though these common methods are not necessarily the most effective.

Hess and Fore [31] note that inclusion of the uncommon techniques, such as gamifying ethics education, facilitating peer mentoring, and having students create their own ethical decision-making processes have the means to supplement the popular methods and “introduce students to additional fundamental components of ethics, thereby contributing to their development of a more holistic conceptualization of engineering ethics” [30, pp. 574]. Additionally, these pedagogical tools need not be restricted to a single course; with ethical potential present in every engineering course, ethical interventions are possible in courses in the form of “micro-insertions” which are authentic engineering experiences such as problem-based learning or community-engaged pedagogies [31] [32]. This has the potential to develop one’s engineering ethics-muscle, making ethical navigation an instinct rather than a constant conscious effort.

Beyond the use of pedagogical techniques, eleven of the articles reviewed by Hess and Fore [31] reported having students engage with established ethical heuristics or at least one form of philosophical ethics. Specifically, consequentialism appeared in 23% of the articles, deontology and justice appeared at a rate of 19%, and virtue at 12%. One work referenced argues that while specific ethics, like philosophical ethics, are not unimportant to the field, it is the applied nature of engineering ethics that benefits the students as it helps develop their understanding of the special obligations as members of the profession [32].

While students can develop their aforementioned engineering ethics-muscle through exposure, the works relying on philosophical ethics note the importance of a student’s understanding of ethical theory in instances of uncertainty such as discerning the applicability of engineering ethics codes in unprecedented circumstances [31]. This is the true test of an established ethics

mindset as the individual must combine their sense of identity (such as their goals, beliefs, and values) with their ethical responsibilities to make a decision that affects others.

Additionally, providing the theoretical contexts that are infused into applied ethics has a potential effect on engineers' commitment to ethics; even Davis [32], who finds applied ethics to be a more effective means of teaching ethics in an engineering culture that seems to include the topic as an afterthought, states that students who understand where the ethical codes originated will better understand their reasonableness and see how consensus was met and therefore be more committed to the code [33]. With engineering ethics education reflecting the needs associated with the ethical code of professional engineers, it is apparent that the current engineering ethics education is an attempt at establishing an engineering ethics sensibility in students rather than simply conveying what is and is not ethical behavior in engineering.

## **Discussion**

In examining the various forms of identity developments, some commonalities can be observed. In this section, we will discuss the common constructs that emerged from the review of personal and social identity development theories, professional engineering identity development theories, and ethical identity development concepts.

### *Personal and Social Identity Development*

The review of three theories pertaining to personal and social identity demonstrated three common themes among them: (1) social identification (2) self-knowledge, and (3) recognition. The first theme of social identification comes from the constructs of social identification in Tajfel and Turner [14], self-categorization in Turner et al.'s [18], and nature-identity and institution-identity in Gee [20]. Each of these constructs emphasize the perception of an individual given their membership of a particular group within a social context; this is often thought of as race, gender, cultural background, or even age. For Tajfel and Turner [14], this specifically looks like determining one's social value depending on their associations as one's social associations convey either positive or negative value. For Turner et al. [18], self-categorization demonstrates a similar concept in which, through numerous levels of abstraction, an individual can be increasingly associated with a group based on their beliefs, values, or attributes relevant in a particular situation. Finally, Gee's [20] nature-identity is used to denote the unchangeable aspects of identity such as race, sex, or cultural background while institution-identity relies on rules and tradition to which one is subject; these require a level of social identification as they matter only due to a society, culture, and/or an institution's declares that they do.

The second theme that emerged across theories was self-knowledge; this stems from Tajfel and Turner's [14] construct of self-knowledge which they identified as a necessary component of establishing a personal identity. This is because self-knowledge is the ability to identify one's own personal thoughts, feelings, and beliefs; knowledge of one's thoughts, feelings, and beliefs is required to create concepts of oneself (i.e., personal identity). Also encompassed in this theme is Turner et al.'s [18] individuality which is essentially one's ability to identify qualities of themselves that both align them with and make them unique from others in their group

associations. Gee [20] similarly included affinity-identity as a factor of identity which relies on one's ability to identify their own unique interests and qualities to make associations with others.

The third theme from the social and personal identity theories comparison was recognition of an individual as a part of a group by others. In Tajfel & Turner [14], social comparison was used to denote the recognized social value attributed to association with a particular group. In Turner et al. [18], depersonalization, or over-identification with a group, could occur due to the paired recognition of an individual and their group as a member of that group. In Gee [20], nature-identity, institutional-identity, and discourse-identity are formed based on the recognition of an individual as a certain type of person within varying social contexts. Each theory relies on the recognition of the presented qualities of an individual to create an association.

### *Professional Engineering Identity Development*

The review of three theories pertaining to professional engineering identity demonstrated two common themes among them: (1) recognition and (2) self-belief. The theme of recognition appeared in Godwin's framework for measuring student's engineering identity development; one aspect of the instrument that characterized recognition was "I have had experiences in which I was recognized as an engineer" [21, pp. 6]. A similar concept was introduced in Jones et al.'s [22] work as belongingness; this concept addresses a student's feeling of acceptance and connection as an engineer to the larger community within their program. Finally, Capobianco et al. [23] included gendered identity which discusses how women developing their engineering identities feel their gender is recognized and mediated in their programs. Each of these examples demonstrate varying degrees of recognition from others as the type of people who can be an engineer as a factor in their development of an engineering identity.

The second theme was self-belief which was first discussed in Capobianco et al.'s [23] work; here, academic self-belief in one's ability to achieve their engineering related goals was an important influence of their engineering identity. Godwin [21] had a similar concept of performance/competence which is one's ability to do well/understand their work in engineering. Jones et al. [22] shares the concept of expectancy which is how well one believes they can complete the engineering work. All three of these concepts convey the need for students to feel confident that they can not only set engineering work related goals but eventually achieve them as well.

### *Ethical Identity Development in Engineering*

In this section, only two theories on moral identity development were compared as the third work included in the section reviewed engineering ethics interventions; comparison of the former with the latter would be comparing apples to oranges. For this reason, the common themes across the two theories of moral development will be discussed as well as concepts from the work on interventions that we felt encourage the development of an ethical identity.

The two papers on moral identity development presented one common theme: unity of self and moral goals. This appeared explicitly in the work of Colby & Damon [30] where moral identity development emerges from life-changing experiences which align an individual's personal

beliefs and values and their goals. These life-changing events are so intense that one's morals are affected to the point of action. The appearance of unity between self and moral goals is less explicit in the work of Blasi [28] which discusses the determination of whether a particular action is both moral and their responsibility to enact. In both cases, an individual is being moved to action by moral sensibility, but in the former it is due to an outstanding event while the latter considers unity of moral self and action based on responsibility.

Hess and Fore's [31] review of engineering ethics education interventions references several interventions which convey the desire of educators to instill an engineering ethics-based identity in students. Each piece of literature reviewed stated learning goals pertaining to ethical sensitivity, and courage. For instance, taking time to explain, dissect, and apply engineering ethical codes and standards were acknowledged as an opportunity for students to understand where the codes they adhere to come from and why they are important; the goal here is for students to identify with the reasoning. Exposure to philosophical ethics was also noted as an intervention which establishes an ethical sensibility in students as it helps them build a toolkit for ethical reasoning; this can be valuable in an industry with technology emerging constantly that requires regulation and ethical application.

### *Offering a Connection to Public Policy Careers*

We have now arrived at the portion of the paper in which we will discuss the opportunity to utilize these common constructs of identity development to consider their application in establishing a public policy career pathway. Targeting the common themes across each form of identity development would be beneficial as their presence in multiple theories essentially increases their potential impact on student's various identity developments. This is because we can address constructs of their identity development without necessarily having to identify which theory they may be identifying with. Additionally, the establishment of common constructs in each of the three types of identity development discussed in this paper helps in limiting the constructs of various forms of identity development that may be aligned with a public policy career to a low but impactful number.

There are five themes in total: (1) social identification, (2) self-knowledge, (3) recognition (common in both personal and social identity development and professional engineering identity development theories), (4) self-belief, and (5) unity of self and moral goals. To better understand the influence of these constructs on the pursuance of a policy career, examples from interviews with participants' who were interviewed as part of a larger study which sought to understand the characteristics of a career in public policy as a technology expert [34] are included. These participants independently referenced their various identities in their responses suggesting that identity is influential in pursuance of a policy career. This led to the present work's desire to begin understanding how one's personal, social, engineering, and/or ethical identity may be developed in a manner that aligns with public policy as a career. Three examples from these interviews will be offered as examples of the five common identity themes that emerged from the analysis to demonstrate their potential relevance to the journey of a policy career. Along with them, possible interventions to encourage these constructs will be offered.

One participant, Jeff, discussed how the lack of visible representation of African Americans in science troubled him. This realization impacted Jeff so greatly that it unified his sense of self and his goals; aware of his social identification, self-knowledge, and the moral implications of the lack of diversity, Jeff says he immediately “began to seek out opportunities to do [STEM]” which then led him to a career in policy. In this example, the alignment between Jeff’s sense of self, emphasis on justice through representation, and determination to make a positive change ultimately led him to his policy career. In engineering programs, there is an opportunity to assist students in establishing unity between their sense of self and their goals. Programs that take a holistic approach to education, where the entire student is relevant to the work, provide opportunities to incorporate the major life experiences, students’ self-knowledge, and social identities students have into their academics and career development. Particular to a career in public policy, the inclusion of these constructs of personal and social identity and ethical identity development would be extremely valuable in a career that benefits from a service mindset and moral decision making. Fostering these attributes can come in the form of connecting students with professionals in policy careers, offering open-ended assignments that encourage students to identify personal passions and infuse them into engineering, or even providing capstone projects with organizations that assist in policy writing.

Another participant, Emma, fulfilled the themes of social identification and self-belief. When asked what improvements could be made to support students who want to participate a career in public policy, Emma recalled how her social identity as a first-generation American negatively impacted her social capital and professional network. This in turn initially prevented the luxury of choosing a career; rather, Emma had to take jobs she was overqualified for in order to meet her financial needs upon graduation. In this circumstance, Emma’s disillusionment was combatted by her self-belief that she was the type of person who could have a successful career in STEM. Hurdles like these, which can arise because of various social identifications, are difficult to overcome. Self-belief has the potential to overcome these hurdles as it encourages a sense of perseverance that is associated with one’s confidence in their abilities to perform tasks and achieve their goals [35]. Both acknowledging and attempting to minimize the effects of negative social identification can provide socialization opportunities to students. Additionally, establishing self-belief in engineering students can be accomplished by socialization of students; allowing them to observe one another’s goal setting and accomplishing those goals will allow them to model their behaviors after each other. Consider long-term, independent projects that model professional projects which require incremental goal setting and accomplishments; often these take place in capstone or senior design projects, but introduction to these types of projects earlier not only expose students to various types of engineering careers, but also allow them to exercise self-belief in lower-stakes opportunities.

Finally, one participant’s experience with identity demonstrated the positive influence of recognition. Irene shared how her journey to her career began in her childhood; her father was a software engineering who always encouraged her STEM interests, going as far as to show her how to create HTML pages for her interests. Her treatment as the type of person who can perform as a software engineering by her father cemented her passion for the work and eventually led to her career in policy. Recognition is a confidence builder; recognition by other people we perceive as knowledgeable on a certain topic conveys that we are also knowledgeable and can therefore perform as they perform. Providing recognition to engineering students can

greatly affect their pursuance of an engineering career, and if the recognition is directly related to a particular career by a leader in that career, then the student may feel more interested and confident in pursuing that career. Providing opportunities to engineering students to receive feedback from, share ideas with, or even potentially collaborate with policy professionals may encourage students to consider a policy career.

### *Limitations*

One limiting factor of this work is the number of papers reviewed for each type of identity development. The aim of each section was to review well-known works that address each type of identity development rather than to deep dive into the long histories of each. In only reviewing the popular theories and works, we may have potentially missed more recent works that have established promising theories of identity development or works that, while not foundational, are still widely referenced. In missing these works, there may have been additional themes that became apparent across theories that could have been included.

An additional factor that limits this study is the inclusion of the interviews that were referenced in this work. These interviews are part of a larger study that is unpublished; this prevents audiences from referencing the work to learn more about the data collection and analysis methods used to conduct and code these interviews. References to these interviews were made in this paper as observations rather than analyzed data. The goal of their inclusion was to provide examples of technology experts in policy who shared their journeys in establishing their career that correlate to themes that emerged from an independent study of the various forms of identity development that can be targeted in establishing a career pathway. While these interviewee's comments on identity were not coded as a part of either this study or the larger research study, we acknowledge that reference to statements made in interviews for a currently unpublished work may call into question the methods used to collect the participant's statements.

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