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Reimagining Behavioral Analysis in Engineering Education: A Theoretical Exploration of Reasoned Action Approach

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Introduction

As a discipline, Engineering Education continues to expand its reach, and subsequently, its methods of analysis. Integrating research from the behavioral sciences and psychology has enhanced researchers' capacities to explore the intricate and multifaceted behaviors inherent to engineering practice and education [1], [2], [3]. These behaviors, encompassing actions directed at specific targets in particular contexts, provide a window into understanding the essence of human conduct. By scrutinizing how individuals operate, form habits, and exert influence through their actions, researchers can examine individuals from a behavior-based perspective.

This paper introduces the Reasoned Action Approach (RAA) framework [4], which emphasizes the pivotal role of intention in behavioral choices. Intentions, in turn, are shaped by personal beliefs, perceived norms, and behavioral attitudes. Whether an individual performs a behavior hinges on their beliefs regarding the behavior, specifically their behavioral, normative, and control beliefs, which reflect their attitude toward, the perceived social acceptability of, and their perceived capability to execute the behavior, respectively. Consequently, the RAA enables researchers to probe the underlying rationales – the *why* – behind these behavioral decisions. These justifications are pivotal, given that behaviors are context-bound and dynamic, shaped by interpretations of one's environment, expectations, self-perception, and aspirations. Currently, such a formulation has not received much recognition in engineering education [5], [6], [7], [8], [9].

The RAA offers a versatile model with profound generalizability to various behaviors, elucidating how individuals perceive actions and decide whether to act upon them. As a result, the RAA presents a novel framework to understand behaviors in engineering education by emphasizing the factors behind behavioral choices. The RAA concentrates on the intricate interplay between beliefs and expectations in the behavioral decision-making process, presenting a distinctive lens to conceptualizing behavior that holds promise for fellow researchers in the field.

Historical Context

The RAA is situated within a comprehensive backdrop of psychological and sociological research spanning several decades investigating motivation and behavior. Consequently, the foundational principles and concepts of RAA resonate with various models within the domain, thereby endowing the RAA with versatile applicability across diverse situations and contexts [10], [11], [12], [13], [14]. To ground this lineage, it's worthwhile to explore the RAA's origins and development.

The RAA framework was the culmination of decades of behavioral research by social psychologists Martin Fishbein and Icek Ajzen, which guided their 2010 book on the approach [4]. This book followed a sequence of theorizing and reformulating beginning in the 1960s [15], [16]. However, work on the RAA traces to a response to the prevailing Marxist emphasis on communal productivity and human essence in the early 20th century [17]. Around this time, predominate psychological perspectives, such as Bills and Brown's [18] theories on work efficiencies, omitted attitudinal influences, prioritizing rationality and outcomes over individual motivation [19].

This perspective began to shift after WWII with studies that investigated task-behavior pairs and action motivators. For example, Ryan [20] posited that tasks, perceptions, memories, and anticipations are causal factors in behavior, while Dulany [21] introduced the theory of propositional control, suggesting that sets of self-instructions characterize behaviors. These early behavioral and attitudinal works marked a significant departure from the prior decades, exemplified by Fishbein's assertion that individuals hold beliefs about behaviors and that evaluations of those beliefs shape their attitude toward them [16].

Subsequently, the following decades witnessed a proliferation of similar behavioral research. Fishbein expanded his earlier model, proposing that intentions foreshadow behaviors [15]. Collaborating with Ajzen at the University of Illinois, the pair introduced subjective norms to incorporate how social dynamics affect intentionality, which culminating in the Theory of Reasoned Action (TRA) in 1980 [22]. The TRA's usage spurred further studies into beliefs, norms, and behavioral expectations [23], [24]. In the mid-1980s, Ajzen extended the TRA's applicability with the Theory of Planned Behavior (TPB) [25], [26], [27], incorporating perceived outcome control and other behavioral models [28], [29], [30]. The domain also witnessed practical applications of these theories during the AIDS epidemic, with governmental bodies, including the National Institute of Mental Health, seeking behavioral intervention mechanisms to impede transmission [31]. Such efforts further refined the theory and its usage [4].

The RAA has evolved through decades of research, offering a framework in engineering education that enables researchers to delve into the factors affecting individuals' behavioral choices. This perspective opens avenues to describe group dynamics, instructional decisions, and other phenomena, enriching our understanding of them within the engineering education context. For instance, a forthcoming conference paper by this paper's authors (blinded for review) aims at scrutinizing behavioral choices within collaborative environments among engineering students, seeking to unveil why students perform certain collaborative behaviors [32] over others. Insights gleaned from such investigations hold the potential to inform instructional strategies, student feedback mechanisms, and classroom organizational frameworks, among others, though results are pending for this investigation. In this way, RAA-enabled, behavior-based investigations present unique opportunities for the systems surrounding behavioral decisions.

To demonstrate the RAA's potential, this discussion will explore its objectives, constructs, and current applications, with a focus on behaviors observed within collaborative environments. Through concrete examples, we aim to illustrate a specific use case and highlight the practical implications of the RAA framework in enhancing our understanding of behavioral decisions within engineering education.

The Reasoned Action Approach

Original Goals

RAA stemmed from Fishbein and Ajzen's recognition of an incongruity within psychology – that diverse behavioral domains, such as voting predictors, racial prejudices, or financial decisions introduced unique variables that defied generalization across different contexts [4]. Further, they noted a lack of robust correlations between alleged domain-specific factors and the behaviors they purported to explain.

Instead, Fishbein and Ajzen asserted that a few distinct explanatory constructs comprise every behavioral decision. Such generalizable constructs apply to any domain and behavioral choice. All the while, this approach attempts to capture the intricate interplay of the various factors influencing behavior, like demographic variables, personality traits, and situational factors. In their words, psychology needed, "A general theory that could be used to predict, explain, and influence behavior in any domain" [4, p. 17].

The RAA, thus, offers a framework for assessing beliefs and perceptions regarding the performance or non-performance of behaviors. By collecting data on attitudes, norms, and intentions, researchers can gauge the relative strength of an individual's beliefs; consequentially revealing the *why* behind behavioral choices. This overarching generalizability marks a departure from earlier social theories, condensing all behavioral decisions into intentions derived from beliefs, attitudes, and perceived norms. The RAA, in essence, addresses the call for a comprehensive, domain-agnostic theory in behavioral psychology.

The RAA empowers engineering education researchers to comprehend the underlying beliefs behind various behavioral decisions, ranging from why an individual might choose to join a design team as a freshman to why another individual decides to depart from engineering during their undergraduate career. The RAA's potential lies in its capacity for generalizability across diverse contexts and situations. By employing consistent constructs and principles, researchers can apply the RAA framework to investigate a spectrum of behavioral phenomena within engineering education, irrespective of the specific context or circumstance. This universality underscores the RAA's potential in unraveling the complexities of human behavior and illuminating the underlying causes driving individuals' decisions across different stages of their educational journey.

Main Constructs

Fig. 1 depicts the principal constructs of the RAA framework, showing the sequential progression of factors integral to behavioral decision-making. Rooted in the RAA's foundational assumption that "people's behavioral intentions are assumed to follow in a reasonable, consistent, and often automatic fashion from their beliefs about performing the behavior" [4, p.

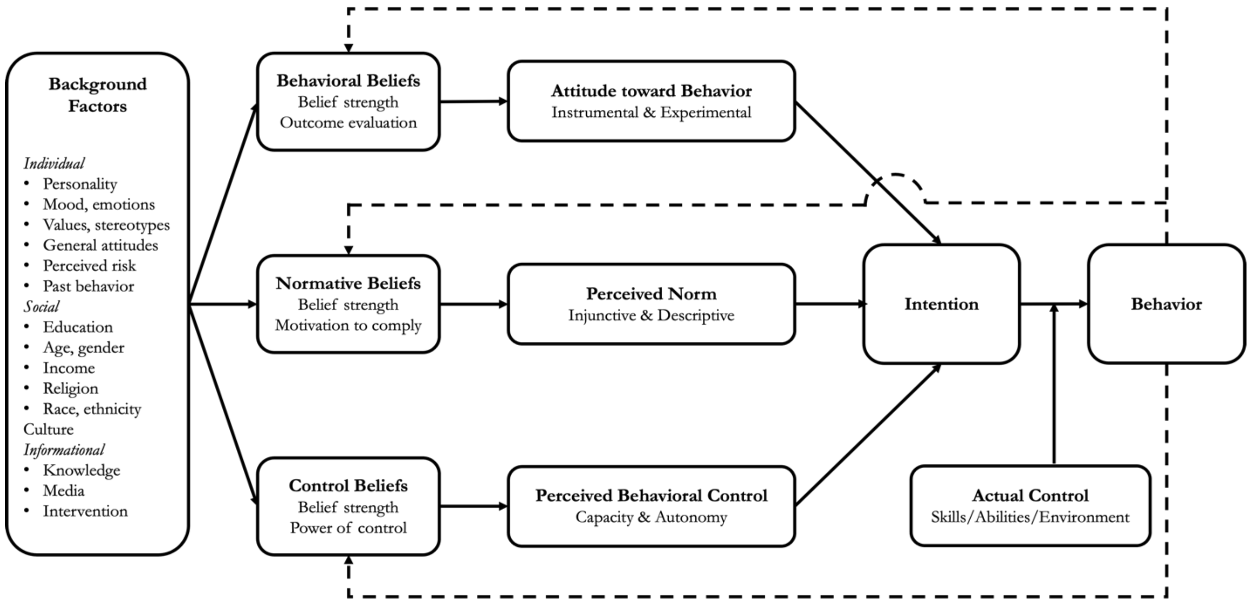

Fig. 1. The Reasoned Action Approach. Source: Adapted from [4]

24], the diagram unfolds from left to right, encapsulating the dynamic interplay of various components.

According to the RAA, an individual's background exerts a formative influence on their beliefs. These beliefs, in turn, crystallize into a configuration of attitudes, capabilities, and perceived norms, collectively shaping behavioral intentions. Subsequently, these intentions serve as precursors to actual behaviors, with the potential moderating influence of actual outcome control – the literal ability to execute a behavior. Each arrow within the diagram symbolizes a weighted influence of one component on another, reflecting the nuanced relationships between background factors, beliefs, attitudes and perceptions, intentions, and, ultimately, behaviors. Notably, however, these relationships may vary in strength. So, background factors, for instance, could exert a more potent influence on normative beliefs than on control beliefs for a given behavior and vice versa for another.

The dashed arrows within the diagram introduce temporal and feedback dimensions, illustrating the chronological progression of behavioral decisions and the feedback loop that informs future choices. These feedback-based considerations underscore the RAA's recognition of the dynamic nature of human behavior, acknowledging that beliefs, attitudes, and intentions can evolve over time, thus enriching the model's capacity to capture the complexity of decision-making processes. In sum, Fig. 1 provides a visual representation of the RAA framework, highlighting the intricate pathways through which beliefs, attitudes, norms, intentions, and behaviors interconnect and evolve. The following sections delve into these constructs and their usages in greater depth.

Behaviors

The RAA places significant emphasis on dissecting behaviors, as articulated by the authors, "It is therefore of utmost importance that the behavior under consideration be clearly identified and properly operationalized" [4, p. 20]. To achieve this precision, the RAA systematically deconstructs behaviors into four elements: an action, the action's target, its context, and the time it was executed. This definition serves to ground behaviors as tangible and actionable entities, such as "providing detailed feedback to capstone engineering team members in the next 6 months," as opposed to more ambiguous actions like "going to the movies." It also underscores the volitional component of the behaviors in question – only behaviors performed voluntarily can be described by the theory. Coercion, force, or other forms of persuasion used to incite behavior fall outside the RAA's purview.

Moreover, the RAA also recognizes the variability in a behavior's specificity and generality. For instance, a behavior could be precisely defined, specifying an action (e.g., providing feedback to all engineering team members) within a designated timeframe (e.g., the next 6 months). Alternatively, a broader formulation might encompass providing feedback to any peer while an undergraduate student. This variability prompts researchers to navigate a balance between the specificity of a behavior and its generalizability, acknowledging that a behavior's level of detail impacts its broader scope. It's this insistence on explicit identification and operationalization of behaviors that highlights the need for clarity in research design, ensuring that behaviors are distinctly defined and expressed.

Intentions

Sitting behind behaviors in Fig. 1, intentions are described as the immediate antecedents of behavioral action, embodying "a person's readiness to perform a behavior" [4, p. 39]. To measure this abstraction, a survey instrument may gauge intentionality by prompting participants to rank their likelihood of performing a specific behavior, such as "I plan to provide feedback for my capstone engineering team members in the next 6 months," on a Likert-style scale [35] ranging from "unlikely" to "likely." Note how the hypothetical prompt implicitly and automatically elicits one's beliefs, attitudes, and capabilities toward the behavior in question. This quantification of intentions serves as a crucial step in the operationalization process, facilitating the empirical examination of these psychological constructs.

Intentions provide the starting point for investigating behaviors, framing the various attitudes, beliefs, and controls that impact the behavioral decision-making process. However, intentions alone are insufficient in predicting behaviors; a student might fail to complete assigned tasks on time due to unexpected project challenges, even if they have strong intentions to meet deadlines. The following sections break down the components that guide intention, providing clarity into the underlying mechanisms driving intentional evaluations.

Attitudes, Behavioral Control, and Perceived Norms

Norms, a distinct facet of the RAA framework, combine to form intentions and are characterized by three essential categories: attitudes toward behaviors, perceived norms, and perceived behavioral control. Commencing with attitudes, defined as the "tendency to respond to some degree of favorableness or unfavorableness to a psychological object" [4, p. 76], this dimension seeks to measure the participant's emotional disposition toward a behavior. For instance, a survey may assess participants' attitudes by asking, "My providing of feedback for my capstone engineering team members in the next 6 months would be…" with responses ranging from "unfavorable" to "favorable." Notably, attitudes toward a behavior evaluate the "overall evaluation" of the behavior, not the affected moods or attitudinal responses it (e.g., anger, happiness) [4, p. 78].

Perceived norms, a construct akin to attitudes, introduce a social dimension by measuring the perceived social pressure associated with performing a behavior. This aspect is further categorized into injunctive norms and descriptive norms, describing perceptions regarding what should be done and of others' tendencies to perform the behavior, respectively. Survey items addressing perceived norms might include items like, "Most people like me think I should provide feedback for my capstone engineering team members in the next 6 months." Ultimately, perceived norms are shaped by an individual's perception of other's attitudes toward the behavior and social expectations about the consequences of the behavior – critical components of intention.

The third component, perceived behavior control, encompasses individuals' perceptions of their capacity or control over executing a specific behavior. This concept aligns with the notion of self-efficacy [36], where actions are contingent upon one's belief in their capability to perform them, as acknowledged the authors: "It can be seen that our definition of perceived behavioral control…is very similar to Bandura's conception of self-efficacy" [4, p. 155]. In this manner, the RAA connects to behavioral theories commonly employed in engineering education [1], [5], [37], and is assessed through questions such as, "If I wanted to, I could provide feedback for my capstone engineering team members in the next 6 months." These questions prompt participants to evaluate potential obstacles to performing a behavior or their direct control over its execution. However, perceived behavioral control is not always directly measurable because factors outside an individual's control are belief- and experience-driven – not necessarily true assessments [38], [39]. Consequently, perceived behavioral control relies on expectations of one's abilities. This inherent limitation underscores the need for an examination of actual control, a concept that will be detailed in a subsequent section.

Beliefs

Taking another step back in Fig. 1, norms, attitudes, and perceived behavioral control within the RAA framework are situated downstream from beliefs, which, in turn, divide into normative, behavioral, and control types. Simply, a belief is the expectation that a particular action will have a particular consequence, where consequences are the societal and behavioral perceptions related to performing that behavior.

For example, normative beliefs portray perceptions of how other individuals act socially. They contribute to the formation of perceived norms, capturing the collective social attitudes about a given behavior. So, perceived norms define a generalized social agent, and are the summation of multiple normative beliefs, each specific to an individual or group. The strength of a normative belief is therefore shaped by an individual's identification with social referents and their motivations to comply with them. As a result, questions related to perceived norms and normative beliefs may ask participants to evaluate what their partner, close friends, or coworkers think about the behavior and whether the participant, outside performing the behavior, tends to agree or conform to these individuals or groups. For example, "When it comes to collaboration, I want to do what my instructor recommends." This item might be paired with, "My instructor thinks that I should provide feedback to my capstone engineering team members in the next 6 months." Combined these items reveal a perceived norm and the degree of conformity to the referent.

Behavioral beliefs are individuals' expectations regarding the consequences of their actions; that behaviors result in specific outcomes. Behavioral beliefs support the concept that prior experience with a behavior can shape intentionality, providing a crucial dimension to the understanding of behavioral decision-making. A behavioral belief could be investigated using items like, "If I provide feedback to my capstone engineering team members in the next 6 months, our team will be more effective." In this way, the item assesses either the perceived consequences of performing the behavior or the evaluation of its outcome.

Lastly, control beliefs pertain to one's perception of their capability to complete a specific behavior. They address the individual's self-perceived ability to execute the intended behavior, contributing to the broader construct of perceived behavioral control within the RAA framework. An example might be, "The amount of coursework might make it difficult for me to provide feedback to my capstone engineering team members in the next 6 months." This item might indicate beliefs about possible control factors that could hinder, support, or impact a behavior's execution.

In sum, the various beliefs within the RAA have a pivotal role in shaping intentions and, consequently, influencing human behavior across diverse contexts.

Background Factors

The final individual-specific attribute, background factors, exerts a profound influence on all behavioral decisions by shaping an individual's social, personal, and environmental contexts. These contexts collectively form the distinctive fingerprint of behavioral, normative, and control beliefs integral to our lives. As shown previously, beliefs amalgamate to guide intention, therefore background factors play a guiding role in shaping intention.

RAA posits that beliefs are acquired through daily interactions with the real world and that individuals' varied experiences are shaped by diverse personal characteristics, including personality, temperament, intelligence, and values. Additionally, social and cultural factors such as ethnicity, race, religion, and education significantly contribute to the formation of these beliefs, alongside exposure to media and other informational sources. The interaction of background factors underscores the dynamic and multi-threaded nature of belief formation, emphasizing the complex network of influences that contribute to individual perspectives and behavioral perceptions. Because of this, background factors are not always directly assessed but are woven into the participants' survey answers.

Actual Control

The constructs described thus far are individual-specific, varying between people and their respective beliefs. Regardless, these constructs coalesce into intentionality, which may be circumscribed by external influences. These external influences are referred to as actual control within the RAA framework, encompassing interventions, past experiences, environmental circumstances, and other, typically external elements that influence behavioral decisions. Fishbein and Ajzen [4] underscore the necessity of acquiring information about individuals' actual control over behavior, emphasizing the importance of obtaining insights beyond stated intentions. This often entails employing follow-up surveys to delve into the intricacies of how external factors exert influence on an individual's ability to carry out a specific behavior. Such surveys might ask, "In the past 6 months, I provided feedback to my capstone engineering team members."

Acknowledging these external determinants within the RAA framework adds a layer of complexity to the understanding of human decision-making, recognizing that individuals' agency is not solely determined by internal factors but is interwoven with the broader contextual landscape.

Feedback

Certainly, behavioral choices extend beyond execution, leading to anticipated and unanticipated consequences. In Fig. 1, dashed lines from behaviors to beliefs illustrate the feedback loop generated by unexpected, unanticipated, or unfavorable outcomes. Faced with such outcomes, individuals reformulate their behavioral, normative, and control beliefs to adapt. Consequently, in similar future scenarios, these assimilated outcomes emerge as the initial links in the behavioral chain. This cyclical relationship underscores the dynamic nature of behavioral decision-making, acknowledging the iterative process through which experiences shape and reshape individuals' beliefs, ultimately influencing subsequent behavioral choices. Additionally, feedback can be confirmatory, reinforcing beliefs about a behavior.

Critiques of the Reasoned Action Approach

Despite its substantial impact [40], the RAA has received criticism and refinement since its initial publication. One notable critique revolves around the RAA's identification of only a few behavioral determinants, prompting other scholars to propose additional influences. For instance, some have argued for considerations such as self-identity [41], [42], anticipated effects [43], [44], and past behavior [45] as important factors influencing behavioral choices. These criticisms introduce additional dimensions to the understanding of behavioral choice and remain debated within the scholarly community [46]. Often, these conversations involve skepticism about the significance of such elements in all behavioral choices and whether they are already part of the RAA in its original form.

The RAA, like other behavioral theories, presupposes that individuals largely control their behaviors through rational cognitive processes [29], [34], [38]. It also assumes that individuals can deconstruct the reasons for their actions. These assumptions are intrinsic to the RAA's methodology, and without it, the framework would be unable to effectively scrutinize behavioral choices. Consequently, they present potential limitations as conscious control over behavioral choice varies widely and people may not follow logical, rational decision-making processes [47], [48].

While the RAA offers a valuable framework for investigating various behaviors, it is important to acknowledge its limitations in capturing the potential influence of power dynamics and other confounding elements. For example, power imbalances within a capstone engineering team could shape individuals' behaviors in ways that extend beyond their personal beliefs, which may not be fully captured by the RAA's focus on individual beliefs and intentions. Similarly, contextual factors may influence behaviors in ways that are not adequately represented by the RAA. In the capstone engineering example, project complexity or time pressures could be such factors. To address these concerns, researchers could incorporate qualitative methods and contextual factor measures, such as assessments of team dynamics or project-specific constraints, to gain a more comprehensive understanding of the complex interplay among individual beliefs, interpersonal and contextual dynamics, and behaviors.

Nevertheless, for researchers in engineering education, numerous behavioral choices of interest, such as those related to student-instructor interactions, collaborative environments, or interactions among students, inherently involve deliberate and volitional behavior that may occur automatically but in alignment with the RAA's principles. The RAA, by emphasizing the role of intentionality in behavioral choices, recognizes that individuals engage in purposeful actions, and their decisions are rooted in personal beliefs, norms, and abilities. Thus, in engineering education, where intentional and individual-driven behaviors frequently occur, the application of the RAA provides a fitting framework for understanding and analyzing these conscious choices.

Researchers utilizing the RAA framework may evaluate these claims to determine whether additional constructs should be included in their investigations.

Instrument Design with the RAA

The RAA defines no single questionnaire as universal to all investigations. Instead, Fishbein and Ajzen assert that researchers must construct a questionnaire unique to the behaviors and populations in question. This section aims to explore the key concepts when creating such a questionnaire, providing researchers with guidance to align their areas of interest with inquiries involving behavioral choices. We hope that fellow researchers can look to the RAA as a framework for investigating phenomena and behavioral choices within their research areas, thereby broadening behavior-based inquiries in engineering education.

Pilot Study

The process of constructing a questionnaire using the RAA begins with formative research, specifically defining the behavior and determining its associated measures. As mentioned, behaviors must be explicitly defined and incorporate a target, action, context, and time. It is similarly crucial to consider the intended audience for the questionnaire during behavior development, recognizing that behaviors may be specific to certain populations.

Once the behavior and target population are delineated, Fishbein and Ajzen advocate for conducting a pilot study to "elicit readily accessible behavioral outcomes, normative referents, and control factors" [4, p. 451]. The RAA-style pilot study engages participants within the population to gather insights into their beliefs concerning the behavior. This includes exploring perceived behavioral outcomes (both advantages and disadvantages), normative referents (individuals or groups influencing if the behavior should be performed), and control factors (elements facilitating or hindering the behavior). These components play a pivotal role in measuring attitudes toward a behavior, perceived norms, and perceived behavioral control.

In addition to behavior-specific details, background information provides valuable insights into the characteristics of the population. These elements contribute to individuals' background factors and influence what might be included or omitted in the pilot survey. For instance, gender-based differences may lead male students to report a greater perceived capacity to complete an undergraduate engineering program compared to their female counterparts [13]. Consequently, both the pilot study and the ensuing questionnaire should incorporate inquiries about demographic information and other pertinent details related to background factors and personality variables, ensuring a comprehensive understanding of the surveyed population.

Questionnaire Development

After formulating a pilot survey, a comprehensive questionnaire can be constructed to delve into participants' beliefs regarding the identified behavioral outcomes, normative referents, and control factors obtained from the pilot study. The questionnaire's items are designed to assess the fundamental features of behavioral, normative, and control beliefs central to the targeted behavior.

To illustrate, if pilot survey respondents highlighted "parents" as significant normative referents in their college major decisions, Likert scale questions can be incorporated into the questionnaire, such as, "When it comes to decisions about my college major, I want to do what my parents think I should do," to evaluate perceived norms. This approach can be replicated for other beliefs and their respective components, ensuring a comprehensive exploration of the participants' perspectives garnered from the pilot data.

For certain behaviors, survey items assessing past behavior may also be significant. For instance, inquiring about students' perceptions of collaborative engineering experiences might necessitate understanding a student's prior experience with collaborative work. Conversely, behaviors such as college major decisions may not require past behavior survey items, given that students may not have prior experience.

Finally, Fishbein and Ajzen recommend the administration of a follow-up questionnaire a few months after the initial survey to inquire about participants' actual control – whether they executed the behaviors between completing the survey and the follow-up. This follow-up assessment enables researchers to gauge participants' abilities to execute the behavior and identify any unaccounted control elements that may have been introduced. However, not all behaviors require follow-up assessments, as researchers may prioritize understanding participants' beliefs toward a behavior over its actual execution.

The RAA in Engineering Education Literature

Engineering education research has traditionally been on a limited set of motivational and behavioral theories, thereby constraining the breadth of conclusions and insights that can be drawn [5], [7], [9]. Compounded by the relative newness of the RAA, this theoretical framework has not garnered substantial attention within the field, particularly in its 2010 formulation [4].

Despite this, instances of research within engineering education utilizing the RAA do exist, offering opportunities for future investigations that may further utilize the theoretical framework. For example, Moloney and Ahern [13] examined Irish adolescent career choices, namely, their decisions to pursue an undergraduate engineering degree. The authors paid specific attention to female underrepresentation in undergraduate engineering by analyzing how different students respond to RAA-based beliefs. Throughout their investigation, the authors incorporated the RAA into methodological decisions, survey design, and data analysis. They also derived policy recommendations aligned with their findings and the RAA, exemplifying the framework's potential and demonstrating its reach in shaping future research.

Similarly, ongoing research by this paper's authors (blinded for review) at Virginia Tech centers around collaborative environments and aims to unveil the underlying conceptions, barriers, and influences shaping specific engineering behaviors [32], contributing to our understanding of the intricacies of engineering design and relationships.

Regrettably, however, RAA-driven inquiries are notably lacking more broadly. Existing studies often draw upon various features of the RAA or its parent theories, TRA and TPB, but at the expense of specific insights. For instance, Matters et al. [49] incorporated the RAA for qualitative thematic analysis, which is a departure from the standard approach. This methodology allowed Matters et al. to claim that "if a faculty member develops such an intention, they will take some personal action to improve diversity and inclusion in their school" [49, p. 8]. They also found that departmental norms impede diversity- and inclusion-promoting actions among faculty because many feel such efforts are not included in their roles. However, because the RAA was not implemented quantitively, it's difficult to assess the concrete factors, and their relative strengths, that resulted in these sentiments.

Similarly, Baytiyeh and Naja [50], [51] utilized the TRA to understand the attitudinal and normative factors influencing the intention to enroll in a Ph.D. program. However, these studies do not employ the RAA, which possesses constructs and methodologies altered from the TRA, limiting their applicability to the RAA. Had the RAA been used, the investigation might have been able to better deconstruct the precise beliefs that comprise students' attitudes and perceptions. For example, rather than survey items aimed at subjective norms and attitudes – the main constructs in the TRA [52], [53] – an RAA-based questionnaire would attempt to delineate between the many beliefs and factors pertinent to the doctoral process, like career goals, encouragement from family, friends, and faculty, and STEM identification [54].

The scarcity of inquiries in engineering education research adopting the RAA may be attributed to its relative novelty or the frequent reuse of established behavioral theories within the field. Consequently, the RAA has yet to gain widespread acclaim in this area, highlighting a potential avenue for future research and theoretical development. To illustrate, researchers could apply the RAA to understand the factors that contribute to students' intentions to persist in engineering programs. Examining how behavioral beliefs (e.g., perceived benefits of an engineering degree), normative beliefs (e.g., social support from peers and family), and control beliefs (e.g., time available to devote to coursework) influence students' decisions to continue or leave their engineering programs could present a unique application of the RAA. Similarly, the RAA could be used to investigate the factors influencing engineering students' career choices and job-seeking behaviors upon graduation. Behavioral beliefs (e.g., perceived fit with a particular industry), normative beliefs (e.g., the influence of family and peers), and control beliefs (e.g., job market conditions) may impact students' career decisions and job search strategies. Researchers could examine such factors using the RAA framework.

By applying the RAA to these pertinent topics, researchers can gain valuable insights into the complex interplay of beliefs, attitudes, and intentions that shape behaviors in engineering education. The findings from such studies can inform the development of targeted interventions, policies, and practices to support student success, promote diversity and inclusion, enhance teaching and learning, and prepare graduates for successful careers in engineering. Conducting research using the RAA in engineering education can contribute to a deeper understanding of the psychological and social factors, potential barriers, and facilitators that influence decision-making processes and behaviors in engineering, ultimately leading to more effective strategies for improving outcomes and addressing the challenges facing the field today.

Conclusion

The RAA, consisting of three integral components – attitudes, interpreted social norms, and perceived behavioral control – comprises a comprehensive framework for analyzing behavioral choices across diverse contexts and situations. The synergistic junction of these influences accounts for a broad spectrum of behavioral decisions, providing a distinctive lens for understanding the determinants of individuals' intentions. This emphasis not only underscores the predictability, modifiability, and explicability of behavior but also positions the RAA as a valuable tool for investigating the intricate interplay between intentions and the multifaceted factors shaping human behavior.

The adaptability of the RAA across various disciplines demonstrates its versatility and enduring relevance in bolstering an understanding of human behavior. As such, there is a compelling case for the adoption of the RAA in engineering education. Embracing the RAA's analytical power in breaking down and predicting behavioral choices can provide valuable insights into the dynamics of decision-making within engineering education settings, offering a promising avenue for enhancing engineering practices and outcomes. Additionally, integrating these findings with existing research on inclusionary spaces [55], [56], [57] and identity development [58], [59],

[60], among others, offers the potential to weave behavioral choices with student development and outcomes.

Behavioral research in engineering education contributes to our understanding of how individuals operate, form habits, and transform themselves and their surroundings through their actions. The RAA possesses the potential to unlock key insights across various domains within engineering education, presenting an opportunity for further exploration and advancement in the field.

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