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What Do Engineering and Other STEM Faculty Need? Exploring the Nuances
of Psychological Needs

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What do Engineering and other pSTEM Faculty Need?

Exploring the Nuances of Psychological Needs

Abstract

We conducted semi-structured interviews of 13 men and 18 women faculty in engineering, math, and physics (pSTEM) to explore their thoughts and feelings about their experiences in the academic workplace. Interview transcripts were deductively and thematically coded according to psychological needs of autonomy, competence, and relatedness. These three basic needs of autonomy, competence, and relatedness were defined from basic psychological needs theory (BPNT), a sub-theory of self-determination theory (SDT). Consistent with previous studies, participants referred to relatedness needs far more frequently than to autonomy and competence needs. To explore the nuances of how all three needs were expressed, a second phase of coding was used to inductively code subthemes within each type of need.

Within relatedness needs, faculty spoke about their collaborations, their connectedness with colleagues and other members of their academic community, and the presence or absence of mentors and related support. Satisfaction of needs for collaboration was far more prevalent among the perspectives of interviewees than connectedness and mentorship support, but these three subthemes were evenly distributed when participants spoke about the frustration of relatedness needs.

In contrast to relatedness needs, needs for autonomy were least frequently mentioned by interview participants. Autonomy refers to an individual's need to have control over their own career pathway including the freedom to choose and the resources to accomplish work consistent with the career pathway as well as the freedom from undue work stress and pressure. Freedom to pursue one's passions and interests was, not surprisingly, the topmost frequent subtheme among autonomy needs.

Like autonomy needs, interview participants rarely mentioned the satisfaction of or frustration of competence needs. Competence needs at work are fulfilled when an individual receives encouraging feedback and guidance from coworkers and supervisors and has opportunities to do work which is neither boring nor prohibitively challenging. Among comments regarding these three subthemes of competence needs, no single subtheme emerged as dominant.

As a whole, interview participants in this study spoke extensively about all three needs, with an average of over 18 distinct references to these needs per interview. While the thematic analysis of autonomy, competence, and relatedness revealed similar results to previous studies, nuances of how these needs are met or frustrated in the workplace emerged in the sub-theme analysis. These sub-themes are important for developing targeted workplace instruments (e.g., survey

scales) that relate directly to potential interventions for better meeting workplace needs in the academe.

Introduction

In engineering and other STEM fields, women tend to have a different perspective than men regarding the barriers they face at work. While evidence from the literature clearly underscores the workplace barriers that women face in the technical workforce, we know relatively little about how these barriers impact their psychological needs and therefore, where interventions would be best focused. This is true in academic workplaces (for faculty and staff) as well as for non-academic workplaces. Further, research has shown that leadership is more effective when building the positive aspects of work rather than focusing on relieving the frustrations that employees face [1]. Thus, a shift in focus from eliminating external barriers to fulfilling employee needs may lead to more effective interventions in improving organizational culture. Consistent with that shift, this workplace study emphasizes what faculty need, rather than the barriers to success that they face, in academia. The basic psychological needs space of both men and women were explored using 31 faculty interviews. A qualitative analysis of the interviews sought to both identify the particular means by which the three basic psychological needs of autonomy, competence, and relatedness are met or thwarted/frustrated and nuances within each type of need that affected faculty success and well-being. Also, potential gender differences in the context of these needs were examined. The results of this qualitative study lay the groundwork for a much larger mixed methods study, designed using the insights gained from this study and related studies in the literature.

Background

What are the basic psychological needs?
This study draws on self-determination theory (SDT) for conceptual framing. SDT is an empirically supported, needs-based perspective on what motivates individuals to behave with willingness and choice rather than acting out of obligation or becoming demotivated altogether. Unlike other needs-based theories, evidence that validates SDT in the workplace is well established [2], [3]. Basic psychological needs theory (BPNT) is a component theory of SDT that puts needs for *autonomy*, *competence*, and *relatedness* at the forefront of psychological health and well-being. Workplaces that either provide low support for or actively thwart these needs are logical candidates for high turn-over, dissatisfaction, and poor productivity. The interview data collected in this study are analyzed in the context of BPNT, both deductively to identify the basic need in play among interviewee comments and inductively to identify subthemes or nuances within each basic need.

Autonomy: Individuals need to feel they are masters of their own destiny and that what they do has been chosen freely rather than out of a sense of obligation to, or coercion by, external factors. Those whose autonomy needs are satisfied feel that what they are doing is consistent with their core values and life purpose [4]. A negative autonomy environment either lacks opportunities for pursuing core values and interests, or actively blocks this pursuit [5].

Competence: When needs for competence are satisfied, individuals maintain interest, engagement, and attention to tasks, persist in their efforts, and experience personal satisfaction and well-being. In contrast, those who do not feel competent in what they do experience reduced motivation and satisfaction. When tasks are boring or too easy, competence needs go unmet. When tasks are too challenging or frustrating, guidance is lacking, or job performance is too heavily critiqued or undervalued, competence needs are frustrated or thwarted. Psychologically, individuals seek out the sweet spot between these two extremes – the optimal challenge [3], [6].

Relatedness: All individuals have a desire to interact with others, experience connection to them, and feel cared for. This sense of being cared for must be perceived as independent of ulterior motives or alternative agendas. The satisfaction of relatedness needs corresponds to a sense of belonging; unfulfilled, frustrated, or thwarted relatedness needs lead to feelings of isolation, stress, and loneliness and are correlated to a wide range of detrimental physical and mental symptoms and illnesses [7].

SDT posits that meeting these basic psychological needs in the workplace leads to more autonomously motivated employees acting out of "... a full sense of volition, willingness, and choice" [8, p.7] as opposed to being controlled (i.e., acting out of obligation) or amotivated (i.e., not motivated to work at all) [8]. Autonomous motivation has two different forms, both of which are supported by the satisfaction of the basic psychological needs. First, employees become more intrinsically motivated when basic psychological needs are met, pursuing their daily work activities out of a sense of enjoyment and interest in those activities. And second, employees who are autonomously motivated internalize extrinsic motivations, such as the values of the organization of their own workgroup [8]. Both types of autonomous motivation are responsible for improved intentions and behaviors associated with boosting physical health and safety [9] as well as increased persistence, greater satisfaction, and improvements in overall well-being [10], [11]. And further, research has shown that the satisfaction of basic psychological needs contributes to improvements in autonomous motivation at work over time and not the other way around [12]. In these ways, SDT clearly supports positive outcomes at work when basic psychological needs are satisfied and negative outcomes when these needs are frustrated. The pathways by which these outcomes are reached may be direct or they may be indirect, but ample empirical evidence exists to validate BPNT within the over-arching context of self-determination theory.

How are basic psychological needs relevant at work?
As early as 1992, empirical evidence for the importance of BPNT at work in the SDT context emerged in the literature. In a study of a work-readiness program at a state psychiatric hospital, Kasser, Davey, & Ryan [13] demonstrated that the satisfaction of psychological needs among workers positively predicted managers' rating of their performance. A year later, in a study of manufacturing workers, basic psychological needs satisfaction was also shown to positively predict job satisfaction and self-esteem [14]. Similar positive outcomes have been demonstrated in a wide range of workplace studies in the twenty-first century. For example, satisfaction of the three basic psychological needs has been clearly linked to greater job satisfaction for employees working in psychiatric facilities [15], better performance evaluations and well-being at work in

the high stress world of investment banking [16], greater overall psychological health in government organizations [17], more hours and greater engagement among volunteers at an animal shelter [18] and greater well-being, job performance, and affective commitment to the job for food industry workers [19]. Further, the mere perception that managers support the basic psychological needs of their subordinates has been associated with reduced somatic system burden (i.e., physical symptoms that have no medical explanation but are related to poor quality of life and disability) [20]. These needs also play a mediating role in some work outcomes rather than a direct role in influencing those outcomes. For instance, Vansteenkiste et al. [21] showed that satisfaction of psychological needs plays an important mediating role in the relationship between the work aspirations of the employee and resulting psychological well-being and work engagement.

Needs for autonomy, competence, and relatedness, however, can have different effects on different outcomes and some needs may have no effect at all while others have significant impact. This heterogeneity has been demonstrated in a meta-analysis of BPNT studies by Van den Broeck et al. [22]. For instance, while each of the basic psychological needs has been positively associated with job satisfaction, performance measures, work effort, and affective commitment to the job and negatively associated with turnover intentions, only needs for autonomy and relatedness were negatively linked to absenteeism while competence was unrelated. With regard to organizational climate, all three psychological needs were significantly and positively associated with positive leader behavior and perceived organizational support while the fit between employee and work environment was significantly and positively linked only to the satisfaction of autonomy needs [22]. In a more recent study in Australia, satisfaction of autonomy and competence needs were associated with less job ambiguity while relatedness needs were associated with greater resilience at work [23]. In a review of daily diary studies, Coxen et al. [24] confirmed that different outcomes are associated with different needs but as importantly, the study also highlighted the fact that significant variation within employees over time merits examining needs satisfaction frequently on a weekly or daily basis.

Does gender matter with regard to basic psychological needs at work?
A limited number of studies have exposed gender differences in terms of how and to what degree the three basic psychological needs are met at work and how they influence workplace outcomes. For example, in a study of investment bankers [16], men found the same work climate to be more supportive of autonomy than women did. Unfortunately, the study was not able to discern whether managers gave women less autonomy support than men or that women simply perceived the same support to be less conducive to autonomy. A similar result was found in a study of workers in the food industry where men reported less frustration of autonomy needs than women [19]. Like the study of investment bankers, it was unclear whether this finding was a result of the way managers treat their employees or of the way employees perceive their managers. Additional gender differences were found in a meta-analysis of 99 workplace study where women reported significantly more satisfaction of relatedness needs than men [22].

While these studies demonstrate gender differences in the satisfaction and frustration of two of the three basic psychological needs, other studies have revealed important gender differences in

how these needs impact work outcomes. For example, a study of food workers [19] found gender differences in the factors that mediate the relationship between BPN and organizational outcomes including job performance and affective commitment. For men, happiness including measures of general, hedonic, eudemonic, and social well-being fully mediated the relationship between the satisfaction of BPN and these work outcomes. But, for women, work engagement rather than happiness mediated this relationship and only partially so. In addition, for men, work engagement bore no significant relationship to BPN satisfaction. In total, these examples provide an important glimpse of how complicated the relationship between BPN and work outcomes can be and how men and women can react differently to both the satisfaction and frustration of these needs.

What do we know about BPNT in teaching, in STEM work, and in teaching STEM?
Studies of basic psychological needs that focus specifically on STEM, on teaching, or on STEM teaching are very limited. Within higher education, Moors et al. [25] measured a lower sense of belonging for women in STEM than either men in STEM or women not in STEM disciplines. (Belongingness corresponds to relatedness in BPNT.) In terms of outcomes, satisfaction of basic psychological needs within STEM has been correlated in part with similar outcomes as in other BPN studies. In a study of elementary school teachers, high satisfaction of relatedness needs in relationships with students was found to lead to greater levels of work engagement and improved positive affect while the same needs satisfaction in relationships with peers had no significant effect [26]. This result is consistent with a study of 300 employees in a single higher education institution which showed that basic psychological needs, as a whole, were not correlated with work engagement, but relatedness by itself was positively and significantly correlated with engagement [27]. The lack of importance that satisfaction or frustration of autonomy needs may play in work outcomes is reinforced by a qualitative study of 1,464 women who left engineering [28], which showed that autonomy was infrequently cited as a reason for leaving work (only 38 times compared to over 200 times for other reasons for leaving). Although the basic psychological needs were not explicitly assessed in the coding approach for the study in [28], participants did refer to needs for achievement (i.e., needs to use abilities and advancement – similar to competence needs) 282 times and to altruism (which included elements of relatedness needs) 239 times. In combination, these studies suggest that relatedness needs may play a greater role in work outcomes among those who teach and that meeting competence needs may be particularly important for keeping women in the engineering workforce.

In summary, the importance of BPN for achieving many positive outcomes, both for the individual and organization, is well documented. However, there is lack of knowledge about how well these needs are being met for university faculty, particularly within STEM. Further, to address the gender gap in engineering, it is important to identify gender differences in how psychological needs are met. There is a significant gap in the workplace literature, academic or non-academic, that specifically looks at women and men in the same study, rather than women alone.

A large-scale quantitative study of engineering faculty, specifically using a BPNT framework, would go far to evaluate these questions. However, because so little is known about how, or if

these needs are being met, it is difficult to design such a study which could focus on the most relevant questions. To identify the most relevant issues at play, a more nuanced understanding of how the three basic psychological needs are met in the workplace is needed. To that end, this study builds on a previous study [29] to not only explore autonomy, competence, and relatedness but to dive deeper into what the satisfaction and frustration of those needs look like in the academic workplace.

Methods

Three research questions emerged from the BPN framework associated with our work. These research questions were addressed qualitatively using data from interviews with faculty in physics and engineering positions in a variety of institutions across the US.

Research Questions

Research Question #1 (RQ1)

Which of the three Basic Psychological Needs were most prevalent among faculty?

To understand what to emphasize in an instrument designed to more broadly understand BPN among faculty, it is useful to understand which of the psychological needs emerge most often from what faculty say, both positively and negatively.

Research Question #2 (RQ2)

How were the fulfillment and frustration of Basic Psychological Needs expressed by faculty?

Knowing which needs seem most important to faculty in their work environment is an important first step. However, this does not go far enough to understand what specific types of support are most helpful or most lacking. Having a more nuanced understanding of how needs are frustrated or fulfilled in the workplace can support the tailoring of resources (time and money) to the most effective interventions for fulfilling those needs.

Research Question #3 (RQ3)

Were there gender differences among the three Basic Psychological Needs?

Because gender imbalance in most engineering disciplines continues to persist, it is important to identify possible gender differences in how faculty perceive their work environment with respect to basic psychological needs. Such insight can support designing specific interventions to greater support women's needs and to level the playing field across genders.

Subjects and Procedures

This qualitative research was exploratory in design, with the goal of uncovering as many possible points of view as possible. Therefore, potential interviewees were selected from a diverse population according to gender and type of institution based on the professional networks

of multiple researchers. Interviewees were recruited exclusively from "pSTEM" disciplines, which include only the physical sciences along with technology, engineering and math.

This approach resulted in interviews with 13 men and 18 women. Most participants worked in engineering departments (8 men and 15 women), but the sample population also included physics (3 men and 1 woman), mathematics (1 man), and computer science (1 man and 2 women). The faculty were intentionally drawn from different types of universities according to Carnegie Classification: doctoral universities with very high research activity (4 men and 11 women), master's college and universities (5 men and 5 women), associate's colleges (1 man and 1 woman), baccalaureate/associate's colleges (2 men and 1 woman), and a special focus college (1 man). The institutions represented each major geographic region of the U.S. (3 Northeast; 2 Southwest; 10 West; 8 Southeast; 8 Midwest) and were both public (9 men and 11 women) and private non-profit (4 men and 7 women) institutions.

Interviews followed a semi-structured protocol, including guiding questions and probes designed to explore the work environments, past and present, that the interviewee had experienced as a faculty member. Interviews were conducted by video platforms. In most cases, interviews were audio recorded and transcribed. When recording was not possible, the interviewer took extensive field notes.

Instrument

The data used in this study were collected with a semi-structured interview protocol that included a total of thirteen questions and relevant prompts (e.g., Could you say more about that? Do you have further examples of this?). The goal of the interviews was to explore the academic communities in which the faculty member participated as well as faculty perceptions of what both an ideal and worst-case work environment would look like. The interview questions relevant to this study are listed in Table 1.

Table 1: Interview Questions

- Could you describe in as much detail as possible the work environment in your home department or unit?
- Can you tell me how the work environment in your home department or unit influences or does not influence your research? Your teaching?
- Could you describe in as much detail as possible the work environment, aside from your home department or unit, that you spend the most time in?
- Could you describe in as much detail as possible the work environment, aside from your home department or unit, that you enjoy the most or find the most fulfilling?
- Could you describe in as much detail as possible the work environment, aside from your home department or unit, that you dislike?
- Is there anything else you would like to share with us about your work environments?

Data Analysis

Once transcribed, the interviews and field notes were thematically coded. A BPNT framework analysis was used to deductively code the data into three categories: autonomy, competence, and relatedness. Subsequently, each identified passage was evaluated to represent need fulfilment or

need frustration, while neutral references were excluded. A phenomenological approach was used, such that the researchers evaluated how a situation was experienced from the participant's own point of view [30]. Further, when a participant discussed an experience, the entire passage was coded as a single mention. If they later brought up the same types of experiences, this was counted as a distinct and new mention, since if the subject was brought up at multiple time, this was interpreted to represent the salience of this type of situation to the participant. After the interviews were coded for the fulfillment and frustration of the three psychological needs, open coding was used to inductively identify different themes within each need type. Three subcategories emerged for each of relatedness, competence, and autonomy.

Results

When discussing the work environment within their academic settings, participants responses spoke to both fulfillment and frustration (active thwarting) of each of the three basic psychological needs (Table 2). Participants as a whole were more likely to address need fulfillment (an average of 11.5 mentions per interview) than need frustration (7.4 times per interview). However, these rates appeared to be gender-linked. Men and women spoke of need fulfillment at similar rates (12 and 11.2 times per interview, respectively), but women discussed need frustration 8.9 times per interview, versus only 5.2 for men.

Table 2: Basic Psychological Needs among Faculty

	Autonomy		Competence		Relatedness		Total	
	Excerpts	Average*	Excerpts	Average*	Excerpts	Average*	Excerpts	Average*
Fulfillment of Needs								
Total	53	1.7	68	2.2	237	7.6	358	11.5
Men	24	1.8	35	2.7	97	7.5	156	12.0
Women	29	1.6	33	1.8	140	7.8	202	11.2
Frustration of Needs								
Total	45	1.5	59	1.9	124	4.0	228	7.4
Men	17	1.3	27	2.1	23	1.8	67	5.2
Women	28	1.6	32	1.8	101	5.6	161	8.9

* Average number of excerpts per interview in each category

Considering the three needs separately revealed important nuance about what types of experiences seem most salient to faculty when reflecting on positive and negative work experiences. Relatedness needs were addressed by far the most often, accounting for two-thirds of all the fulfillment reflections and over half of all the need frustration comments. Of the remainder, competence needs (both fulfilled and frustrated) were identified slightly more frequently than autonomy. When analyzed by gender, even more striking patterns emerged. Men and women described fulfillment of their autonomy and relatedness needs at about the same rate. However, men mentioned the fulfillment of competence needs 50% more frequently than women did (2.7 times per interview for men and 1.8 times per interview for women). In contrast, when discussing situations that frustrated basic psychological needs, it was autonomy and competence that men and women discussed at similar rates. However, the difference by gender in frustration

of relatedness needs was striking, with women (5.6 times per interview) bringing it up more than three times as often as men (1.8 times per interview).

Relatedness Needs

Relatedness needs were by far the most prevalent need mentioned in the interviews. Interviewees spoke to relatedness needs along three major subthemes: collaboration, connectedness, and mentorship. A closer look at how men and women expressed their perspectives regarding how well relatedness needs were satisfied or frustrated in the workplace is summarized in Table 3.

Table 3: Relatedness Needs among Faculty

	Collaboration		Connectedness		Mentorship/Support		Total	
	Excerpts	Average*	Excerpts	Average*	Excerpts	Average*	Excerpts	Average*
Fulfillment of Needs								
Total	145	4.7	57	1.8	35	1.1	237	7.6
Men	66	5.1	24	1.8	7	0.5	97	7.5
Women	79	4.4	33	1.8	28	1.6	140	7.8
Frustration of Needs								
Total	61	1.0	30	1.0	33	1.1	124	4.0
Men	19	1.5	3	0.2	1	0.1	23	1.8
Women	42	2.3	27	1.5	32	1.8	101	5.6

* Average number of excerpts per interview in each category

Need for collaboration

Responses coded in this subcategory referred to the quality of working relationships and professional teamwork, with both negative and positive examples. Both male and female faculty reflected on their desires for meaningful, balanced, and fruitful collaboration with their colleagues, both in research and in teaching. Those who had found successful collaborations were quick to point out what a difference it made in their work environment. For example:

> A lot of our courses, especially the early ones, are interdisciplinary…. One of the great things about this work environment compared to my experience at <previous institution> was that a lot of my interactions are with colleagues from other areas and so there's a lot more opportunity for sort of learning new perspectives on things and new ways of thinking about problems. *(Male faculty member, special focus college)*

In contrast, frustration of relatedness needs in the context of collaborations ranged from a lack of opportunity to unethical behavior regarding intellectual property and ideas. For instance:

> I've also had scenarios where people sort of see me as a particular kind of thinker and they would bring me in on their groups, and then they'll get me involved in conversation and try to get me to help with developing proposals and stuff like

that. Then…they will take my ideas and not attribute it to me, in really unethical ways.... *(Female faculty member, doctoral university)*

Interviewees expressed ideas about needs for collaboration more frequently than connectedness and mentorship in the context of relatedness needs. Overall, faculty indicated that collaboration is a positive rather than a negative experience. Both of these trends were true for both men and women, although the ratio of fulfillment to frustration in collaboration was noticeably lower for women than men. Thus, while women are on the whole enjoying positive collaborations, the interview results suggest that they are also more likely to experience difficulty in this area.

Need for connectedness:
While collaboration emphasized working relationships, participants who spoke to relatedness needs through the theme of connectedness focused on the quality of social relationships among coworkers. Unlike with collaborations, a specific work-related task was not integral to a connectedness experience. These informal interactions were highly valued in faculty work environments, and not necessarily for a specific purpose but simply for the opportunity to enjoy the company of colleagues:

> We have gone through phases where we will meet every other Friday at a local place and have a couple beers and stuff like that. So, there's a lot of informal interactions and hanging out. *(Female faculty member, doctoral university)*

Unfortunately, some informal interactions with colleagues did not foster positive relationships. Frustration of relatedness needs could be caused by antagonistic behaviors:

> There have been some strong personalities in the department that have caused some pretty significant conflicts over the years that affect everyone in negative ways. *(Female faculty member, master's college)*

Even when work relationships were not actively hostile, the absence of any connectedness left faculty members feeling hindered at work:

> It's the lack of relationship and isolation that really inhibits me from being the best that I can be in this field. *(Female faculty member, doctoral university)*

There were noticeable gender differences in connectedness. Both men and women described more positive than negative feelings. However, it was striking that women also expressed nearly as many instances of need frustration as of satisfaction, whereas the experience of frustration of connected needs was almost non-existent in the interviews with men.

Need for mentorship and support:
Mentorship refers to interactions with colleagues which are supportive for the participants' professional and career growth. Faculty mentorship can take shape in many different ways [31], and any of these were included in this category. Because this code was a sub-theme within

relatedness needs, these passages focused on the relational aspects of interactions with others, who might be characterized as not only mentors but also sponsors, advocates, or role models. In this study, mentorship needs could be related to long-term career pathways or to short-term job tasks. Some institutions assign junior faculty to be mentored in a formal program. But other mentoring experiences are often more informal and can involve not only more senior faculty but also peers of similar rank. For example, a positive example of relatedness need satisfaction in the context of mentoring describes a general climate of colleagues cheering each other on:

> There's a lot of peer mentoring that goes on in our program and so at some level everybody has at least one person looking out for them. I think that's huge. *(Female faculty, doctoral university)*

On the other hand, some faculty felt somewhat adrift or left on their own to figure out how to do their jobs, even as they faced new responsibilities. This participant described the absence of the input that she felt she needed.

> No one was ever really a mentor to me and told me this is a good way to do things. It was just like, "Okay go ahead and teach this class." That was kind of the only direction I got. *(Female faculty, master's university)*

Mentorship needs revealed gender differences. Men did not bring it up much at all, but when they did it was positive. Instead, women talked about mentorship much more often and were almost as likely to report needs frustration as need satisfaction.

While relatedness needs came to mind the most frequently by far as faculty reflected on their work environment, experiences dealing with competence needs were also expressed.

Competence Needs

Similar to relatedness needs, faculty talked about their competence needs along three key sub-themes: feedback (from others), guidance, and growth (opportunities). A closer look at how men and women expressed their perspectives regarding how well competence needs were satisfied or frustrated in the workplace is summarized in Table 4.

Table 4: Competence Needs among Faculty

	Feedback		Guidance		Growth Opportunities		Total	
Fulfillment of Needs								
	Excerpts	Average*	Excerpts	Average*	Excerpts	Average*	Excerpts	Average*
Total	32	1.0	14	0.5	22	0.7	68	2.2
Men	15	1.2	9	0.7	11	0.8	35	2.7
Women	17	0.9	5	0.3	11	0.6	33	1.8
Frustration of Needs								
Total	23	0.7	16	0.5	20	0.6	59	1.9
Men	5	0.4	12	0.9	10	0.8	27	2.1
Women	18	1.0	4	0.2	10	0.6	32	1.8

Needs for feedback

Feedback is a way for an individual to assess their competence by comparing their work to a standard. This can come from the task itself when something works well (*e.g.,* working with students feels rewarding because of what students get out of it); from self-comparison (either with one's own past performance or comparisons with others); or from perceiving respect from others. For example, one interviewee explicitly spoke to the importance of seeing the fruits of their labor:

> What I enjoy and find the most fulfilling is a sense of accomplishment. That's why I like academia because at the end of each year you get to talk to the graduates and sort of see the fruit of your work. And especially talking to alumni it feels like what I've been spending all my time on is worthwhile. *(Male faculty member, master's university)*

Opportunities to positively compare one's own work to others also supports competence needs:

> The fact that we co-teach here I think is actually also something that helps with that because you have the opportunity to see other people and how they do things. *(Male faculty member, special-focus college)*

Feedback needs also involved perceptions of whether faculty felt that own work was valued or respected by their colleagues. This was expressed as need satisfaction:

> We make sure all of the faculty are fully respected and there is an appreciation for whatever type of research you want to do, whether it be technical- or education-based. (*Male faculty member, doctoral university)*

But this also showed up in need frustration:

> So, I did have some interesting experience where faculty have told me outright that whatever activity or whatever assignment we did in class they just skipped it because they didn't think it was worthwhile. *(Male faculty member, doctoral university)*

Need for guidance from others

In addition to being met through feedback, competence needs can also be met by receiving appropriate guidance from others that enables an employee to succeed. Faculty expressed the importance of guidance by whether they received clear expectations about teaching, were provided access to shared resources such as course material repositories, received useful tips for improving grant proposals, or were given explicit and stable goals for promotion and tenure. Guidance could be provided from many different sources, including peers, advocates, supervisors, students, staff, and others in the work environment. For example:

> It's by and large very independent, mostly interacting with students rather than colleagues, but supportive. Any professor I have gone up to is happy to answer

questions and talk to me and encourage me.... *(Female faculty member, master's university)*

When competence needs are frustrated within the context of this theme, guidance may be confusing, ambiguous, or absent:

It's gotten better but it's still: "Oh, we want you to do research, but we don't know how to support you in giving you space or students or really understanding what the research enterprise entails." *(Male faculty member, doctoral university)*

Need for growth opportunities
Competence needs can also be satisfied via opportunities for growth. A healthy work environment should present a tolerance for some errors or failures, which allows for risk-taking and growth. It should also provide optimal challenges. This involves work that is difficult and varied enough to be interesting:

I'm surrounded by people from all over the world with incredible talents. I interact with young people on a daily basis which is always stimulating.... *(Male faculty member, doctoral university)*

Work that was deemed boring or tedious instead led to frustration of growth opportunities:

I hate the scholarship when it has to do with rewriting things over and over again. *(Female faculty member, master's college)*

Need for growth was also frustrated when faculty felt that it was not feasible to accomplish the requirements of their jobs:

I had thought that with the shared power people would step up, that wasn't the case on the grants I was running, sometimes people were coming through and sometimes they weren't, but I was still responsible for what people said they were going to do. So, I dealt with students or postdocs not getting work done by trying to control most of it, by setting up very specific tasks, and asking for regular reports and all of that. That has sort of backfired, and the result is that over the last several years I increasingly don't want to work with students, so I'm designing research studies that don't involve students, which is terrible. It's not why I started this job. *(Female faculty member, doctoral university)*

Autonomy Needs
Autonomy needs were expressed in the ways in which faculty found their jobs interesting and consistent with their own passions and under their own control for how they selected and executed their job duties. Table 5 summarizes the perspectives on workplace autonomy shared by faculty. Study participants spoke to autonomy needs being satisfied or frustrated along three major subthemes: freedom to express themselves and to pursue interesting work, sufficient resources to pursue their interests, and absence of extreme work stress.

Need for freedom

Faculty expressed autonomy need satisfaction when they felt the freedom to choose the particular projects or tasks on which they worked. They appreciated being allowed to establish their own approach to courses they taught:

> It's actually been pretty beneficial because most of the classes I teach, there's only two of us that teach the class. So, there's taking turns on it and so if we want to try something different or look into something like changing a textbook, it's very easy to do. Anytime you're working with one or two other people instead of a large group it just makes things a lot easier. We've had a lot of flexibility which is good. *(Male faculty member, master's university)*

Conversely, the desire for freedom felt frustrated when structural or other constraints prevented their desire for innovation and autonomy:

> It goes through all these levels just to get any sort of minor change through. And that it takes a year or two years. I just feel like it stifles creativity. You feel like hitting your head against the wall whatever you try to do something new. So if there could be a way to streamline that process or be more encouraging of curricular innovation, I think that would be something I would like to improve upon at my work environment. *(Female faculty member, master's university)*

Scholarly pursuits were important to the work environment for many faculty. Faculty felt excited or energized by the nature of the academic career, which allows for freedom of scholarly pursuits:

> The freedom of inquiry, the openness, the intellectual challenge every day, to have the ability to be creative, to address problems that nobody else has solved. *(Male faculty member, doctoral university)*

Of course, when someone felt that their scholarship choices are being externally constrained or not valued, it caused a frustration of autonomy:

> The very nature of us in academia is that we are all very passionate about our own areas and problems that we think are important. There is often tension about which one do you highlight. *(Male faculty member, master's university)*

Table 5: Autonomy Needs among Faculty

	Freedom		Resources		Absence of Stress		Total	
	Excerpts	Average*	Excerpts	Average*	Excerpts	Average*	Excerpts	Average*
Fulfillment of Needs								
Total	48	1.5	3	0.1	2	0.1	53	1.7
Men	24	1.8	0	0.0	0	0.0	24	1.8
Women	24	1.3	3	0.2	2	0.1	29	1.6
Frustration of Needs								
Total	19	0.6	5	0.2	21	0.7	45	1.5
Men	8	0.6	0	0.0	9	0.7	17	1.3
Women	11	0.6	5	0.3	15	0.7	28	1.6

* Average number of excerpts per interview in each category

Need for resources
In the context of autonomy needs, faculty also spoke to having (or not having) sufficient resources available to support their work goals. This might include having adequate staff support to allow faculty to excel in their teaching and scholarship work:

> The staff critical from every perspective. They support … the advising side; we have laboratory facilities where staff are critical in making sure that the facilities are up and running and information technology that everything is working the way it should. *(Female faculty member, doctoral university)*

On the other hand, tight budgets or some management decisions left faculty feeling frustrated and unable to do their jobs in a way that was satisfying for pursuing their autonomy:

> So it's a direct result of having resources cut and creating an almost toxic environment. *(Female faculty member, doctoral. university)*

Need for the absence of excessive work stress
Last but not least, excessive work stress got in the way of faculty autonomy. Such stress relates specifically to the demands of the job on one's time and personal well-being. Faculty don't necessarily mind work stress; a demanding job can be rewarding when given the opportunity to manage one's own workload and use of time. For example:

> So, one of the other things that I enjoyed about teaching is you're on this quarter system or you're on a semester system, but things come to an end. You could stop; you can assess how things went and you can start again and make changes, but you have this finite place where you know things are going to stop. *(Female, mixed baccalaureate/associate's college)*

Not surprisingly, only two faculty brought out in their reflections on their work environment any positive feelings regarding the demands of their job. Work stress emerged in the conversation only when it because a burden or a barrier:

There's just this constant push 24/seven to outperform and out succeed, and I think you lose the forest for the trees because, we came there and we got hired because we're good at something. We don't need the added stress or anxiety or pushes to do good work. I think at academic institutions and my experiences at <this institution> is that my stress level is off the charts and that can be toxic. You just get exhausted and you get burned out and it's really hard to come out of that. *(Female faculty member, doctoral university)*

Not everyone felt so overwhelmed by work stress, but they were still frustrated when they felt they were always being asked to do more, more, more:

It's okay to be asked to do stuff and given time to do it but just to keep adding things to your workload – just in general that is a discouraging thing in the workplace. *(Male faculty member, associate's degree college)*

Independent of these subthemes, no gender differences emerged in how faculty experienced their workplace environment with respect to autonomy needs. Both men and women expressed slightly higher rates of satisfaction than frustration, and they both brought autonomy up much less frequently than relatedness.

Discussion

When given the opportunity to talk about their work environment in general, the pSTEM faculty interviewed all spoke to circumstances or situations that express their basic psychological needs being fulfilled or frustrated. Given that the outcomes of having these needs met (or not) have been well-demonstrated in the research literature, it is important to assess these patterns. It is encouraging that in this study, faculty express satisfaction more frequently than frustration across all three BPNs. This study provides insight into the particular ways faculty express these needs as well as gender differences in those expressions.

Research Question #1

Which of the three Basic Psychological Needs were most prevalent among faculty? (RQ#1)
When discussing the quality of their work environment, relatedness is by far the most relevant basic psychological need among pSTEM faculty. It seems that despite (or perhaps because of) the independent nature of academic work, interactions with colleagues, both social and work-related, are critical to the positive (or negative) way that faculty experience and reflect upon their work environment.

Interviewees also spoke to competence and autonomy needs but these needs seemed far less important in their influence on work environment. Both of these are needs that faculty would be more likely to overlook, simply by the nature of academic work. Jobs in academia generally require a high degree of competence so simply having a position as a faculty member could support competence needs. Most people would also expect faculty jobs to be inherently high-autonomy,

so unless something was particularly outstanding (positively or negatively) it just might not come to mind as important to the work environment.

Research Questions #2 and #3

How were the fulfillment and frustration of Basic Psychological Needs expressed by faculty? (RQ#3)

Were there gender differences among the three Basic Psychological Needs? (RQ#2)

The fact that relatedness needs dominated conversations with faculty is consistent with previous studies [29]. This study took those needs a step further by taking a more nuanced look at the three needs by identifying subthemes within those needs. There are areas where faculty seem to be doing well. Within autonomy, the freedom to pursue one's own interests was, by far, the most often mentioned by faculty, and it was largely describing need satisfaction. The other autonomy subcategories (sufficient resources to pursue those interests, and absence of extreme work stress) skewed negative. But it is important to note how rarely either of these were mentioned at all. Thus, it seems that these sub-themes are not particularly relevant to faculty's perception of their work environments, unless they are being actively thwarted – which seems to be rare. Furthermore, no gender differences seemed to emerge from expressions of autonomy. This differs from prior workplace studies, which reported higher satisfaction of autonomy needs for men than women in the food industry [19] as well as in another male-dominated field – investment banking [16]. However, academia is already such a high-autonomy job that this might overcome effects of gender bias, at least with respect to autonomy.

In the context of competence needs, the most salient subtheme was feedback, and faculty generally felt that the this was well-satisfied. However, women were more likely to express frustration with respect to receiving feedback. This is consistent with a study of the engineering workplace in which women, in comparison to men, felt like they got less honest feedback at work [32]. This higher level of frustration with feedback may also be a manifestation of gender bias. For example, student evaluations are often more critical of female instructors, especially in technical courses.

Finally, in the context of relatedness needs, what seems most salient to faculty are collaboration experiences, both positive and negative ones. The cultural expectation for the academic workplace is sometimes closer to independent contractors than a team of workers. This approach would seem to fit well with the nature of faculty who tend to prefer the high autonomy inherent to many academic positions. But this study suggests that faculty really appreciate opportunities to work collaboratively in a supportive community where the talents of their highly skilled colleagues can benefit everyone. It is also notable that a gender gap appears to be present in relatedness needs, with women much more likely to report frustration of those needs. Other studies have pointed to a differential gender climate in engineering academia. For example, [33] determined that women in workplaces that are numerically male dominated and subject to a male-normative culture (both true in engineering) experience high levels of gender identity threat

compared to both non-STEM women and STEM men. Gender identity threat, in turn, thwarts satisfaction of belonging and relatedness needs.

Mentorship support also presented an intriguing pattern within relatedness needs. Men discussed need satisfaction and frustration regarding mentorship at similar rates. The same was true for women. However, women were more than five times as likely to bring up mentorship at all. This could indicate that the many programs designed to deliberately increase and improve mentorship for women have been noticed and largely effective. Or, it could mean that the need for mentorship is simply greater for women due to their underrepresentation in engineering. Perhaps, men don't really think about or notice when they benefit from a supportive or mentoring relationship – because it is always easily available.

Even more striking among gender effects was how different men and women expressed their needs in terms of connectedness. Men almost never mentioned frustration of this need, while for women frustration was almost as frequent as satisfaction. Because women brought up experiences of positive connectedness at the same rate as men, this could imply that there is little gender difference in the importance of this need to faculty. High levels of frustration with lack of connectedness, however, may suggested that it has important negative impacts on women. Prior engineering workplace studies have identified the absence of a sense of belonging for women. (For a review, see [34]). Since sense of belonging is closely related to connectedness, the results of this present study are consistent with other studies, and together suggest that future work in this area is important to supporting women in engineering.

This study presents an interesting contrast with prior workplace studies of gender and BPNT. A meta-analysis of workplaces across many different types of industries determined that women experienced a higher degree than men of satisfaction of relatedness needs [22]. This study also shows similar *satisfaction* of relatedness needs by gender. However, the *frustration* of needs showed this was much more salient for women than men in engineering. This provides support for the possibility that it is not the case that women have a greater focus on relatedness than do men, but rather the engineering workplace is particularly unfriendly to women.

Limitations

This study is qualitative in nature and the results may not be generalizable. However, the data represent faculty in a broad range of pSTEM settings and have highlighted the importance of studying academic work life from a basic psychological needs perspective, including the particularly important role that relatedness needs play in a fulfilling career in academia. Our interview results have cast the net on psychological needs in the academic workplace and provide key insights into how to design and focus a survey in future research to investigate the satisfaction and frustration of psychological needs in the academic workplace, both at a BPN level and at a more nuanced level through the subthemes exposed in this study.

Furthermore, the phenomenological nature of this qualitative research attempts to see the data from the participant's own point of view. However, the researchers are themselves pSTEM academics and their own experiences in this work may have unintentionally biased the thematic

analysis of the interview data. Since, at this time, the authors are making no claims as to the generalizability of this study, the impact of such potential bias is likely to be minimal.

Implications

Our findings lend support to the idea that faculty do indeed seek to meet the three basic psychological needs for themselves in their careers. Across many people, and across many types of institutions, each with different job demands, faculty expressed similar psychological needs pertaining to their workplace environment. Thus, our interview results add further empirical support to the notion that these needs are in fact basic (universal).

Understanding where faculty feel fulfilled and energized, as well as what frustrates them could ideally be used to build effective interventions or structures to better fulfill the needs of all faculty. Further, to make progress on the goal of increasing the number of female faculty in pSTEM academic positions, it is useful to understand how women's experiences, as framed by BPNT, differ from those of male faculty.

For new engineering faculty, however, this study calls for greater attention to relatedness needs at the start of a faculty career. With the many pressures that fall upon new faculty to produce, publish, and excel, relatedness needs can often be deferred or neglected altogether. Given their critical importance to so many work outcomes, however, it is important to carve out the time and habits to attend to and fulfill relatedness needs. Productivity without attending to relatedness needs, or with frustration of those needs, is simply not sustainable.

Concluding Remarks

Table 2 indicates good news that both men and women chose to discuss substantially more distinct examples of need fulfillment than of frustration. However, a closer examination of the three individual needs of autonomy, competence, and relatedness reveals important insights into the psychological fabric of the academic workplace. Both male and female faculty speak to relatedness needs far more often than needs for autonomy and competence. But women speak to the frustration of those needs at much higher rates that men do. And, much of the frustration of relatedness needs appears to be related to harmful collaborative relationships and the absence of mentorship or sponsor support. While these results are not necessarily generalizable, they point to the need to focus on relatedness in a broader survey or quantitative study in future research. Future research can also leverage these interview results as well as survey results from a larger population to formulate strategies and interventions to better meet the needs of faculty in the academic setting.

Acknowledgements

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