Faculty perceptions of and approaches for fostering engineering student motivation at Hispanic Serving Institutions

Abstract

This research paper examines faculty perceptions of and approaches towards fostering students' motivation to learn engineering at Hispanic-Serving Institutions (HSIs). By aligning learning experiences with what motivates Hispanic or Latinx students, the resulting higher student motivation could increase the sense of belonging for underrepresented populations in engineering, ultimately improving student retention and persistence through meaningful instructional practices. Motivation to learn encompasses individuals' perspectives about themselves, the course material, the broader educational curriculum, and their role in their own learning [1]. Students' motivation can be supported or hindered by their interactions with others, peers, and educators. As such, an educator's teaching style is a critical part of this process [2]. Therefore, because of the link between a faculty member's ability to foster student motivation and improved learning outcomes, this paper seeks to explore how engineering faculty approach student motivation in their course designs at Hispanic-Serving Institutions.

Humans are curious beings naturally drawn to exploration and learning. Self Determination Theory (SDT), popularized by Ryan and Deci, describes the interconnection of extrinsic (external) and intrinsic (internal) motivators, acknowledging the link between student's physiological needs and their learning motivations [1], [3]. SDT proposes that students must experience the satisfaction of competence, autonomy, and relatedness for a high level of intrinsic motivation. Further, research indicates that appropriately structured, highly autonomy-supportive teaching styles that foster intrinsic motivation are associated with improved student outcomes [2]. However, further research is needed to observe how faculty prioritize students' innate needs and how they seek to foster student motivation in tangible ways within their engineering classrooms. Therefore, this paper seeks to answer the following research question: What educational supports do engineering faculty at HSIs propose to embed in their curricula to increase their students' intrinsic motivation?

To answer this question, thirty-six engineering educators from thirteen two- and four-year HSIs from across the continental United States were introduced to the SDT and approaches for supporting students' intrinsic motivation during a multi-institutional faculty development workshop series. Participants were asked to reflect on and prototype learning experiences that would promote intrinsic motivation and fulfill students' needs for competence, relatedness, and autonomy to learn engineering [1]. Data were collected through a series of reflection worksheets where participants were asked to describe their target stakeholders, define a course redesign goal, and generate possible solutions while considering the impact of the redesign on student motivation. Qualitative analysis was used to explore participant responses. Analysis indicates that the participants were more likely to simultaneously address multiple motivational constructs when attempting to improve student motivation, rather than addressing them individually. Some of these approaches included the adoption of autonomy-supportive and structured teaching styles. As a result of this research, there is potential to influence future faculty development opportunities at HSIs and further explore intentional learning experiences that promote and foster intrinsic motivation in the engineering classroom.

Introduction

A motivated person is often described with positive adjectives, such as happy, energetic, and driven. Student motivation is similarly tied to positive outcomes in an educational context, such as higher engagement, enhanced learning, and increased persistence and retention [1]. Highly motivated students often exhibit positive learning behaviors, retain what they study and learn, and become more driven towards setting and attaining goals related to their learning [4].

Naturally, students' motivation can be enhanced or hindered by their instructors' interaction with them through classroom dynamics, assessments, and overall teaching styles. The intentional actions taken by teachers to increase their students' motivation are commonly referred to as a teacher's motivating style [5],[6]. According to Alterman, motivating styles that embrace scaffolded and highly autonomy-supportive approaches positively impact student outcomes [2]. Those adopting more controlling teaching styles are associated with negative student outcomes.

The importance of student engagement and motivation, and the link between a faculty member's ability to foster student motivation and improved learning outcomes, cannot be overstated. In this interaction, faculty perception and beliefs about students are important factors that influence their teaching approach and ability to foster inclusive and motivating learning environments. For instance, scholars such as Canning explored faculty perception and beliefs regarding their students' intelligence [7]. They found that faculty with fixed mindsets yielded demotivated students and a higher achievement gap among marginalized students [7]. For Latinx students, faculty support plays a vital role in higher student satisfaction, persistence, and retention when instructors decide to serve students through meaningful relationships that mentor and inspire [8].

Motivation is crucial in engineering programs, where student retention and persistence are negatively impacted due to rigorous academic demands, historical lack of access to specific populations, and other social inequities. Engineering in the United States has traditionally been an unwelcoming field for Latinx students and other underrepresented populations [9] [10]. While there is an equal likelihood of Latinx students graduating from either Hispanic-Serving Institution (HSIs) or Predominantly White Institutions (PWIs) [11], there is a positive correlation of higher Latinx student engagement and motivation at HSIs [12]. Therefore, with this positive correlation in mind and the fact that HSIs educate about a third of Latinx engineering graduates in the United States, careful examination of HSI faculty's ability to foster motivation could provide valuable insights to help increase the representation of diverse populations in the future STEM workforce [13], [14], [15].

HSIs are two- and four-year higher-education institutions enrolling 25% or more Latinx students [15]. Research suggests that HSIs are better equipped to enhance Latinx students' outcomes than non-HSI settings through target initiatives, such as student-centered support programs and inclusive curricula that connect to their cultural identity [16]. HSIs are exemplars of inclusive curricula through intentional incorporation of diverse instructional activities and assessments [17] as well as through alignment of identities with learning objectives in their course [18] [19][20]. Despite the contemporary research insights on the value that HSIs provide to Latinx students, there is still a need for inclusive and learner-centered practices within engineering departments [21].

Therefore, this paper explores how engineering faculty at HSIs perceive and approach student motivation in their course designs at HSIs and report tangible approaches faculty could use to improve students' motivation to learn. We hope to influence future faculty development opportunities at HSIs and further explore intentional learning experiences that promote and foster intrinsic motivation through autonomy-supportive teaching styles in the engineering classroom. In doing so, we could directly impact and increase the representation of underrepresented populations in engineering.

Theoretical Framework

Many theories seek to explain the intricacies of motivation. Among those commonly applied in educational contexts are Self Determination [1], Expectancy-Value [22], Future Time Perspective [23], and Social Cognitive [24] theories of motivation. This research study adopts the Self-Determination Theory (SDT) as our theoretical framework. In SDT, Ryan and Deci explain how motivation can be described in terms of amount (e.g., little or a lot of motivation) and type or source of motivation [1]. Motivation can also be thought of as spanning a continuum that illustrates the type and source of motivation an individual can experience (Figure 1). At one end of the continuum lives amotivation, or the unwillingness to act. In the center of this continuum, motivation is guided by external (i.e., extrinsic) factors. Finally, opposite amotivation is motivation influenced by intrinsic (i.e., internal) factors.

As an example of the range of motivations described in SDT, consider the scenario of students entering higher education. Ambrose argues that at this transition point, students are confronted with greater autonomy in the decision-making process regarding their educational pathway and learning approaches while dealing with competing goals (e.g., work, homework, new relationships) that demand their attention, energy, and, of course, motivation [4]. In this demanding process, SDT would argue that a student might be motivated to do their homework for the extrinsic motivators, such as the reward of a good grade or the fear of academic punishment (i.e., external factors). Alternatively, a student might also be intrinsically motivated by the mere pleasure of overcoming a challenge or learning something new (i.e., internal factors). In a nightmare scenario, students might also experience amotivation due to external pressures, lack of support, or controlling learning environments that hinder their ability to achieve their educational goals.

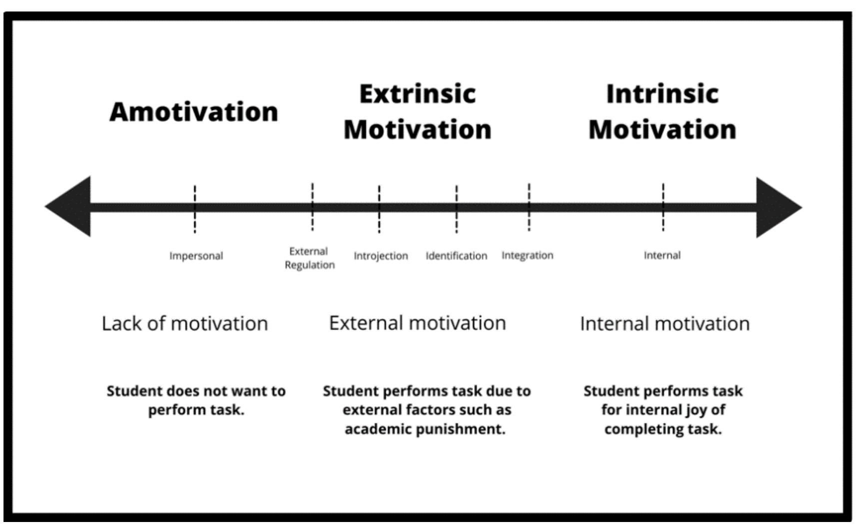

Figure 1. Simplified taxonomy of human motivation adapted from [1]

Despite our best efforts as educators, students do not always respond with innate interest, but rather are influenced by extrinsic factors, such as an opportunity for extra credit. Deci describes such behaviors resulting from extrinsic motivation as those actions inspired by a separable outcome. Humans often perceive external forces as negative or ingenuine and can respond to them with hesitancy or resistance. SDT proposes that even though external motives can present themselves in students through resistance to assignment completion or disingenuous behavior towards a topic, external motivators are not necessarily negative if students internalize the value of the task and can perform them with autonomy. To describe this, Deci proposes the constructs of *identification* and *integration*. Identification refers to the perception of value, and integration refers to the perception of agency in performing an activity. In integrating and internalizing, students can experience *external regulation* by performing for the sole purpose of satisfying external pressures, such as a teacher's or parent's demands. Similarly, students might experience *introjected regulation* by performing to impress fellow students or a sense of pride. As students gain more autonomy, they begin to experience *identification* by seeing alignment between their personal values with a prescribed goal. Finally, students can experience *integrated regulation* through the assimilation of a goal with their values and needs. As the internalization of value and sense of volition increases (from external regulation to integration), students become more self-determined and engaged [1].

Intrinsic motivation is at the forefront of human curiosity and cognitive development. Naturally, this type of motivation is abundant at an early age as toddlers encounter new experiences via their newly found senses and the joy of exploration [1]. Unlike extrinsic motivation, intrinsic motivation is not influenced by external factors, but is derived from the internal satisfaction or joy of performing an activity. Therefore, individuals can be intrinsically motivated to complete certain learning activities. Similarly, activities can be designed to foster or respond to students' intrinsic motivators. Scholars, such as Skinner who sought to describe what makes certain activities intrinsically motivating [2]. They found that intrinsically motivating activities are those that satisfy innate psychological needs, specifically competence (i.e., your sense of your ability to be successful at the assigned task), autonomy (i.e., your sense of control and agency over one completes a given task), and relatedness (i.e., your sense of connection to the content as well as support from the community around you). Instructors can then help students satisfy these needs in an educational context through intentional approaches and enhance intrinsic motivation.

Scholars have since sought to understand how instructors can satisfy these physiological constructs through their teaching practices and interactions with students [2]. Alterman proposed the *Circumplex model* (Figure 2) to describe various teaching styles, divided into four quadrants (Chaos, Autonomy-support, Control, and Structure)[2]. The model's vertical axis denotes a spectrum from *low directiveness* to *high directiveness*. The horizontal axis denotes a spectrum from the *need thwarting* to *need support.* According to their model, Alterman posits that students' physiological needs are fulfilled in highly *autonomy supportive* and *structured* teaching practices and hindered in *chaos* and c*ontrolling ones*.

This paper uses SDT to analyze the approaches taken by faculty at HSIs to promote intrinsic motivation through intentionally seeking to fulfill their students' physiological needs of competence, relatedness, and autonomy in their learning environment. We also seek to observe which motivating styles are adopted by faculty and their interaction in construct fulfillment.

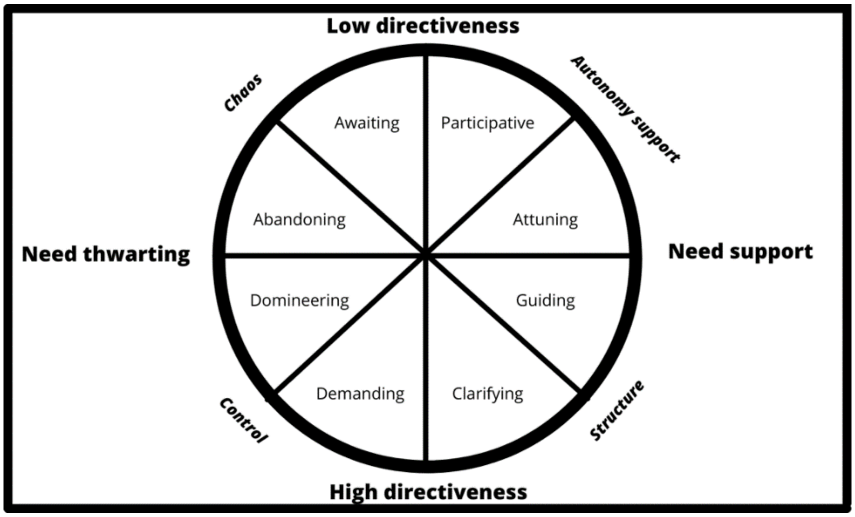

Figure 2. Graphical representation of Alterman's Circumplex model adapted from [2]

Methods

This study is part of a larger mixed-methods research project that focuses on engaging engineering educators at HSIs to share non-obvious needs and existing successes at their institutions. As previously mentioned, the study described in this paper explores how engineering faculty approach student motivation in their course designs at HSIs. Therefore, we sought to answer the following research question:

> *What educational supports do engineering faculty at HSIs propose to embed in their curricula to increase their students' intrinsic motivation?*

Two Multi-Day Faculty Development Workshops

Thirty-six engineering educators from 13 two- and four-year HSIs participated in one of two workshops in the spring of 2018 [25]–[27]. During these workshops, participants were introduced to curriculum design through various lenses, such as design thinking, students as empowered agents, and intrinsic motivation.

The facilitators approached the workshop design from an exploratory perspective, seeking to learn from and with the participants. During the workshops, participants practiced and reflected on these pedagogical tools and approaches through a series of worksheets and interactive discussions. For instance, participants were prompted to reflect on their personal classroom experience and how they perceive student motivation.

Using the Design Thinking framework of inspiration, ideation, and implementation [28],[29], [30], participants were asked to engage in a student-centered design process to explore and prototype approaches that could be used to address their students' motivational needs and thereby enhance their intrinsic motivation [31]. Participants worked on worksheets individually and in small groups.

Participants

A total of 36 attendees participated in the workshop. Of attendees, 29 completed the design activity (Table 1). For this study, faculty with full-time teaching roles were included in the analysis (n = 24). Out of these faculty members, 58% (n =14) were instructional faculty and 42% were tenure-line (n = 10). Table 1 provides additional demographic information. Table 2 uses the classification system developed by Núñez, Crip, and Elizondo for HSIs to describe the institutions represented at the workshop series [32].

Table 1. Participant Demographics

		Gender Identity			*Ethnicity*
Participant Group	**Total**	**Female**	**Male**	**Transgender**	**Latinx**
Tenure-line	10	30%	70%	0%	10%
Full-time Instructional	14	36%	58%	7%	36%
Design Activity Participants	24	33%	63%	4%	25%
Workshop Participants	36	25%	72%	3%	39%

Table 2. Institutions Represented at the Workshop Series Classified using Núñez et al. System for HSIs (2016)

HSI Classification	Number	Carnegie Classification	Admission Rate Ave (Min-Max)	Total Students	%Hisp Ave
Urban-Enclave Community College	2	Baccalaureate/ Associate's Colleges: Associate's Dominant	Open/100%	48378 (40754-56001)	53%
Big Systems Four-Years	9	Doctoral Universities: 1 Moderate, 3 Higher, 5 Highest research activity; 7 Pub., 2 Priv.	68% (36% -100%)	28670 (40754-56001)	46% (23%-80%)
Rural Dispersed Community College	1	Baccalaureate / Associates's Colleges: Associate's Dominant	Open/100%	5564	49%
Small Communities Four- Years	1	Master's Colleges & Universities: Small Programs	22%	2009	26%

Data Collection

This paper focuses on responses to the GAPA worksheet, a design activity that encouraged participants to prototype ideas by aligning efforts with tangible approaches that enhance student learning. When using the GAPA worksheet (Figure 3), participants were able to identify key stakeholders tied to educational **G**oals, possible interactions to achieve those goals in the form of **A**ctivities that could generate **P**roducts, and approaches for the **A**ssessment of the overall goal completion [33]. Participants were first given an overview of how workshop facilitators applied the GAPA framework at their respective institutions. Participants were also introduced to SDT, and examples were shared of how the workshop facilitators intentionally sought to foster intrinsic motivation on their respective campuses. They then complete a poster-size GAPA handout to explore opportunities for enhancing their students' intrinsic motivation at their institution. Workshop facilitators also encourage faculty members to hang their completed worksheets on the wall and participate in a modified Gallery walk [34]. After feedback and discussion, participants were asked to refine a final GAPA worksheet of their design.

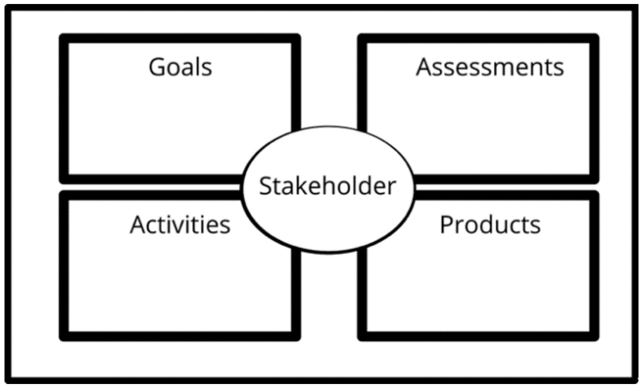

Figure 3. Simplified GAPA worksheet adapted from [33]

Data Analysis

Our exploratory study applied an inductive and deductive approach to analyze and identify emerging themes from participants' responses [35]. Worksheets were collected, and participants' responses were de-identified and scanned. Responses were transcribed, organized, and coded using Microsoft Excel. Two graduate research assistants analyzed the data, presenting it weekly to the research team to maintain consistency and reliability. Discrepancies and initial findings were discussed, and extensive discussion of codes and the coding process was maintained for the entirety of the data analysis process before results synthesis.

The analysis involved a meticulous reading of the completed GAPA worksheets to capture insights from participant responses. Participant responses were placed in narrative format and deductively coded according to the corresponding motivational construct: relativeness, competence, and autonomy. For example, if a participant's solution statement read: "Show real-world problems and motivate them (students) to solve their own way. Institute different types of classroom activities to reach all or most students, such as workshops, active learning, group projects. Strive towards 90 - 95% pass course at C or better." the narrative was coded as shown in Table 3.

Table 3. Motivational Construct Coding Example

Motivational Construct	**Tools/techniques for influencing stakeholder motivation**
Relatedness:	"Show real-world problems"
Competence:	"Institute different types of classroom activities to reach all or most students such as workshops, active learning, group projects. Strive towards 90-95% pass course at C or better."
Autonomy:	"Motivate them to solve their own way."

The inductive analysis of artifacts from these workshops led to articulating themes that encompassed participant approaches in designing to fulfill stakeholder (student) needs. These emergent themes are discussed in the following sections.

Limitations and Appropriate Interpretation of Results

The current study explores the perceptions of 24 self-selected engineering faculty participants from across the southern United States. Conducting similar exercises with students could yield different results for the same educational innovations presented in this study. Because some activities during the workshops included group work, worksheet answers might have been influenced by other participants' perspectives. As a result of the small sample size and limited worksheets, it is unclear which constructs participants may have been intentionally targeting and which were unintended byproducts. For instance, a participant could have addressed competence as a byproduct of addressing autonomy or vice versa.

Furthermore, the study does not seek to make any claims regarding the efficacy of the identified motivational approaches but instead uses the results to contextualize what is being done at HSIs. Additionally, while many of the following approaches are commonly applied in various institutional contexts, we sought to focus on the innovative work happening in the HSI engineering context. Our goal is to center and celebrate what is being done, not compare with other institutional contexts [36]. Comparison of contexts between minority-serving institutions and predominantly white institutions can, directly and indirectly, perpetuate unwarranted stereotypes.

Results and Discussion: Participant Approaches and Emergent Themes

Across all faculty participants, 44 interventions were proposed to improve students' educational experiences. These interventions were categorized by motivational construct (Figure 4). This analysis indicates that participants were equally likely to address competence or relatedness independently (both n = 3). No participant acknowledged autonomy on its own. Instead, participants were more like to address constructs in combination, with all but six of the interventions addressing two or more constructs. The following sections illustrate participants' proposed interventions in each category.

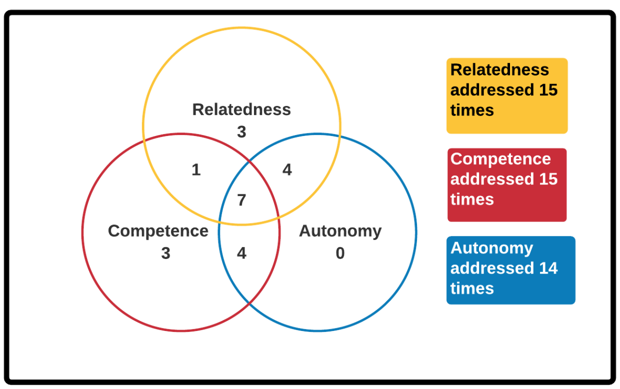

Figure 4. Number of proposed educational approaches categorized by motivational construct (relatedness, n=15; competence, n=15; and autonomy, n=14)

Competence

When seeking to enhance their students' sense of competence, the participants' approaches were categorized into three emergent themes: 1) opportunities for knowledge application, 2) targeted practice, and 3) pedagogical approaches in the classroom (Table 4). Participants expressed how, to achieve competence, students should be exposed to diverse ways of applying content knowledge outside of the class. For example, participants recommended giving opportunities for students to “us[e] engineering skills to produce solutions” and have “exposure to real-world experiences.” These observations are consistent with the literature. For example, students who are exposed to activities outside of the classroom experiences, such as undergraduate research experiences, have been shown to develop communication, problem-solving, and critical thinking skills [37].

Table 4. Summary of themes identified from participants’ approaches to developing their students’ sense of Competence (i.e., sense of mastery and ability to be successful at an activity).

Theme	**Participant Approaches (Direct Quotes)**
Extracurricular opportunities for knowledge application	Introduction to design thinking
	On-campus research
	Opportunity to use engineering skills to produce solution
	Internships
Targeted practice and curricular supports to provide feedback to students	Math packets and labs to focus on student weaknesses
	Access to labs in order for students to approach problems of CS with confidence.
	Rubrics for assignments
	Integrated labs in lectures as early as sophomore year
	Textbook website tools
Pedagogical approaches to support individualized learning in the classroom	Differentiated math levels
	Highlight important points to prep for quiz
	Adding subgoals to activities
	Guided-Inquiry book
	Project-based learning
	Different types of classroom activities to reach most students

Participants also described how competence could be fostered through *Targeted Practice* by the “integration of labs early in student academic career” and using “website tools to address weaknesses." Research indicates that instructors who provide positive targeted feedback can increase their students’ understanding of content, enhance student motivation to complete a task, and yield better performance [4]. Similarly, instructors who intentionally scaffold their teaching (e.g., provide explicit classroom rules and expectations) can provide a stable and predictable learning environment for students [38]. In terms of the Circumplex Model, intentional course structure provides an opportunity to enhance students’ sense of competence through *guiding* or *clarifying* teaching styles [2]. Participants also expressed the role of diverse pedagogical approaches to achieve student motivation. Participants used phrases such as “project-based learning” and “differentiated math levels” to convey approaches that could be considered. Literature supports diverse pedagogical approaches and their positive correlation with higher student competency satisfaction [39]. For instance, a contemporary approach that has gained traction is differentiating learning, where teachers adapt teaching practices to ensure that students of diverse academic backgrounds feel included [40].

Relatedness

At its core, education is about building meaningful relationships between students, faculty, and the broader community. Participants described approaches for building a sense of relatedness in three main overarching themes of 1) relatedness in community, 2) relatedness to individualized student needs and interests, and 3) relatedness in field and content (Table 5). For *relatedness in community,* participants expressed how students could achieve meaningful relationships with other students and faculty by being provided opportunities to join "face-to-face or virtual learning communities" or by taking steps to *build student-faculty relationships* by adopting an "open-door policy to discuss reference letters, internships jobs or grad school." Research shows that supportive instructors can promote a positive classroom environment by developing relationships with their students [41] and supporting multiple student-student interpersonal interactions [42]. Faculty could further enhance relatedness by *connecting content to student interest* through intentional "design and attend[ing] to students' interest and relevance" or by *adopting student-centered accommodations* as simple as providing "audio-book textbooks."

Table 5. Summary of themes identified from participants' approaches to developing their students' sense of Relatedness (i.e., sense of connection with others and belonging).

Themes	**Participant Approaches (Direct Quotes)**
Community	
Student-to-Student: Student learning communities	Create face-to-face and virtual learning communities
	Make team projects a requirement
	Peer mentoring program for students
	Peer to peer feedback on projects
Student-to-Faculty: Building student-faculty relationships	Open-door policy to discuss reference letters, internships jobs or grad school
	Have students engage in dialogue to explore barriers and concerns
Individualized student needs and interests	
Faculty-to-Student: Centered accommodations	Audio book textbooks
Faculty-to-student: Connecting content to student interest	Feel that they are in the right class and comfortable with course material
	Design and attend to student's interest and relevance
	Make lectures enjoyable
	Provide hobby and self-interest activities
	Relating class problems to variety of fields
Field and content	
Field and content: Industry & professional interaction	Real life/world problems
	Go over elements of CS implemented in complex common tools/devices
	Industry professional provides feedback on selected project

Finally, participants expressed how students could grasp relatedness to their *field and content* through first-hand experiences, such as "early professional connections and real-world experience." Regarding the Circumplex Model, participants adopted *attuning* motivating teaching styles by relating to students' interests and backgrounds [2].

Autonomy

An individual's perception of free will appears to be at the forefront of human motivation theories. It is the sense of volition that allows a person to feel in control of their life decisions and influence the goals and outcomes for which they strive. Traditionally, the instructor-student relationship has been a power dynamic in which the instructor has the upper hand and is the source of all knowledge [43]. As such, instructors have been conditioned to be hesitant to yield autonomy to their students in fear of classroom chaos [2]. In our study, participants were similarly hesitant and less likely to forfeit autonomy than competence or relatedness in their classroom. Despite these findings, participants expressed comfort (n = 7) in addressing autonomy in conjunction with other constructs. Literature indicates that the use of teaching styles that emphasize student autonomy support does not equate to a lack of teacher presence or control [2], [44], [45], [46].

Table 6. Summary of themes identified from participants' approaches to developing their students' sense of Autonomy (i.e., sense that one has a choice and control of one's learning).

Themes	Participant Approaches (Direct Quotes)
Student involvement in program/course refinement	Feedback on different phases of project
	Assessment on team dynamics
	Graduating seniors' input for future advising
	Input on syllabus
	Student to demand that courses have continuity
	Getting feedback from students about projects
Class content ownership/student agency	Students choose/create assignment
	Independent generation of creative products, self-guided activities
	Student to demand that courses have continuity
	Allow them to design their team experience
	Motivate students to solve problems their own way
	Students teach class one day
	Students design own problems
	Students lead class

Regarding the Circumplex Model, research indicates that autonomy-supportive teaching practices bring numerous benefits, such as better learning outcomes, higher engagement as well as allowing teachers to better nurture learners' emerging interests and values [2]. In our study, participants yielded autonomy in two general ways (Table 6), illustrated by the emergent themes of 1) student involvement in program/course refinement and 2) class content ownership and student agency. When building autonomy by increasing *student involvement in program and* *course refinement*, participants suggested approaches such as allowing students to provide "input on syllab[i]" and "feedback on different phases of project[s]." In the case of giving students *class content ownership/student agency,* participants expressed how students could be given autonomy by allowing them to "choose or create their own assignment," by providing opportunities for students to "teach class one day," as well as by "motivating" students to practice autonomy and "solve problems their own way."

As observed in Alterman's Circumplex Model, motivating teaching styles can be adopted to increase students' intrinsic motivation [2]. For instance, adopting a participative teaching style can allow students to be more engaged in their learning if they are involved in the classroom choices [42], [47]. An attuning approach can spark interest through meaningful assignments that resonate with students' interests or backgrounds. Similarly, faculty can increase persistence by adopting guiding approaches that scaffold content. Finally, faculty can take a clarifying approach that sets clear expectations that enable stable learning environments.

Implications and Future Work

Despite the intricacies of motivation, faculty developers should continue introducing faculty to targeted and holistic approaches for fostering their students' sense of motivation. In this process, developers can help faculty identify interventions that optimize construct combinations that better fulfill their students' needs. For instance, as noted in the current study results, faculty may be hesitant to address autonomy independently but feel more comfortable doing so in combination with relatedness and or competence.

The results of this study could also be used to develop further an inventory of techniques to foster students' motivation. This inventory could be integrated into faculty development programing as a reference tool for engineering faculty at HSIs. Similarly, this study can inspire emerging HSIs to design curricula that integrate the lessons previously shared to enhance students' learning. Ultimately, the findings of this study should contribute to building a sense of belonging within the engineering community and help increase diversity in the workforce.

Nonetheless, it is important to specify that future research should consider multiple institutional contexts, as this study focused on faculty at HSIs. With that in mind, we hope to continue encouraging broader dialogue to better serve students through inclusive practices and targeted faculty development that yields long-lasting educational impacts for students of all backgrounds. Future work should also address approaches to improving the intrinsic motivation of faculty members themselves. A similar exercise could be implemented with engineering educators as the primary stakeholder. Finally, future research should also explore the immediate and longitudinal impact of these educational experiences intended to impact student motivation.

Conclusion

As the Latinx student population in the United States continues to grow, institutions must seek to address their unique students' interests and needs. In particular, a student's motivation to learn encompasses their perspective about themselves, the course material and broader educational curriculum, and their role in their own learning [3]. This motivation can be both supported or hindered by their interactions with others, peers, and educators. Faculty members must understand and pursue tangible approaches that satisfy their students' physiological needs and enhance their intrinsic motivation. This paper, therefore, summarizes the outcomes of our analysis of how engineering faculty approach student motivation in their course designs at Hispanic-Serving Institutions. The qualitative analysis of artifacts from these workshops led to articulating themes for how participants sought to address the motivational constructs in Deci's framing of intrinsic motivation. Data analysis suggests that faculty are more likely to address motivational constructs in concert with each other rather than targeted alone. Participants expressed a wide variety of tangible approaches that could help satisfy their students' needs and propel them along the SDT continuum towards intrinsic motivation. As a result of this research, there is potential to influence future faculty development opportunities at HSIs and further explore intentional learning experiences that promote and foster intrinsic motivation in the engineering classroom.

Acknowledgments

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References

[1] R. M. Ryan and E. L. Deci, "Intrinsic and extrinsic motivations: Classic definitions and new directions," *Contemporary educational psychology*, vol. 25, no. 1, pp. 54–67, 2000.

[2] N. Aelterman, M. Vansteenkiste, L. Haerens, B. Soenens, J. R. J. Fontaine, and J. Reeve, "Toward an integrative and fine-grained insight in motivating and demotivating teaching styles: The merits of a circumplex approach.," *Journal of Educational Psychology*, vol. 111, no. 3, pp. 497–521, Apr. 2019, doi: 10.1037/edu0000293.

[3] E. L. Deci and R. M. Ryan, "The general causality orientations scale: Self-determination in personality," *Journal of Research in Personality*, vol. 19, no. 2, pp. 109–134, Jun. 1985, doi: 10.1016/0092-6566(85)90023-6.

[4] S. A. Ambrose, "How Learning Works: Seven Research-Based Principles for Smart Teaching," p. 328.

[5] D. W. Reeve, "There is an urgent need for engineering leadership education," *Engineering Leadership Review*, vol. 1, no. 1, pp. 1–6, 2010.

[6] T. Wubbels, M. Brekelmans, P. den Brok, and J. van Tartwijk, "An Interpersonal Perspective on Classroom Management in Secondary Classrooms in the Netherlands," in *Handbook of classroom management: Research, practice, and contemporary issues*, Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers, 2006, pp. 1161–1191.

[7] E. A. Canning, K. Muenks, D. J. Green, and M. C. Murphy, "STEM faculty who believe ability is fixed have larger racial achievement gaps and inspire less student motivation in their classes," *Science Advances*, vol. 5, no. 2, p. eaau4734, Feb. 2019, doi: 10.1126/sciadv.aau4734.

[8] J. C. Hernandez and M. A. Lopez, "Leaking Pipeline: Issues Impacting Latino/A College Student Retention," p. 24.

[9] M. M. Camacho and S. Lord, *The Borderlands of Education: Latinas in Engineering*. Lanham: Lexington Books, 2013.

[10] D. R. Simmons and S. M. Lord, "Removing Invisible Barriers and Changing Mindsets to Improve and Diversify Pathways in Engineering," *Advances in Engineering Education*, 2019, Accessed: May 27, 2021. [Online]. Available: https://eric.ed.gov/?id=EJ1220293

[11] S. M. Flores and T. J. Park, “The Effect of Enrolling in a Minority-Serving Institution for Black and Hispanic Students in Texas,” *Res High Educ*, vol. 56, no. 3, pp. 247–276, May 2015, doi: 10.1007/s11162-014-9342-y.

[12] K. Fosnacht and J. N. Nailos, “Impact of the Environment: How Does Attending a Hispanic-Serving Institution Influence the Engagement of Baccalaureate-Seeking Latina/o Students?,” *Journal of Hispanic Higher Education*, vol. 15, no. 3, pp. 187–204, Jul. 2016, doi: 10.1177/1538192715597739.

[13] Excelencia in Education, “Hispanic-Serving Institutions (HSIs): 2018 -19 Fact Sheet,” Excelencia in Education, Washington, DC, 2020.

[14] Hispanic Association of Colleges & Universities, “2018 Fact Sheet: Hispanic Higher Education and HSIs,” HACU Office of Policy Analysis and Information, 2018.

[15] National Academies of Sciences, Engineering, and Medicine, “MSI Report - STEM workforce,” The National Academies Press, Washington, DC, 2018. [Online]. Available: https://doi.org/10.17226/25257

[16] G. A. Garcia, “Decolonizing Hispanic-Serving Institutions: A Framework for Organizing - Gina Ann Garcia, 2018,” *Journal of Hispanic Higher Education*, Oct. 2017, Accessed: Mar. 18, 2021. [Online]. Available: https://journals.sagepub.com/doi/full/10.1177/1538192717734289

[17] G. A. Garcia and O. Okhidoi, “Culturally Relevant Practices that ‘Serve’ Students at a Hispanic Serving Institution,” *Innov High Educ*, vol. 40, no. 4, pp. 345–357, Aug. 2015, doi: 10.1007/s10755-015-9318-7.

[18] M. R. Kendall, M. Denton, N. H. Choe, L. M. Procter, and M. Borrego, “Factors Influencing Engineering Identity Development of Latinx Students,” *IEEE Transactions on Education*, vol. 62, no. 3, pp. 173–180, Aug. 2019, doi: 10.1109/TE.2019.2909857.

[19] Y. Montoya, A. E. P. Rimada, E. I. Delgado, I. N. Webb, and M. R. Kendall, “Developing Leaders by Putting Students in the Curriculum Development Driver’s Seat,” 2015.

[20] A.-M. Nuñez, E. M. Ramalho, and K. K. Cuero, “Pedagogy for Equity: Teaching in a Hispanic-Serving Institution,” *Innov High Educ*, vol. 35, no. 3, pp. 177–190, Jun. 2010, doi: 10.1007/s10755-010-9139-7.

[21] I. M. Hasbún and A. Coso Strong, “WIP: Identifying Structural and Cultural Characteristics of Hispanic-Serving Institutions in Engineering Education - A Morphogenetic Approach,” Virtual, 2020.

[22] J. S. Eccles and A. Wigfield, “Motivational Beliefs, Values, and Goals,” *Annual Review of Psychology*, vol. 53, no. 1, pp. 109–132, 2002, doi: 10.1146/annurev.psych.53.100901.135153.

[23] J. Husman and D. Shell, “Beliefs and Perceptions about the Future: A Measurement of Future Time Perspective,” *Learning and Individual Differences*, vol. 18, pp. 166–175, Apr. 2008, doi: 10.1016/j.lindif.2007.08.001.

[24] A. Bandura, “Social Cognitive Theory: An Agentic Perspective,” *Annual Review of Psychology*, vol. 52, no. 1, pp. 1–26, 2001, doi: 10.1146/annurev.psych.52.1.1.

[25] M. R. Kendall, A. Coso Strong, I. Basalo, G. Henderson, D. Ural, and M. Williams, “Co-Designing an Engineering Education Research Agenda,” Public Research Report, 2019. Accessed: Sep. 11, 2019. [Online]. Available: http://eel.utep.edu/hsi/workshop-outcomes.html

[26] G. Henderson, M. R. Kendall, I. Basalo, and A. Coso Strong, “Co-Designed Research Agenda to Foster Educational Innovation Efforts Within Undergraduate Engineering at HSIs,” Tampa, FL, 2019.
[27] M. R. Kendall, A. Coso Strong, I. Basalo, and G. Henderson, “Rethinking Engineering Education at Hispanic Serving Institutions,” 2018. http://eel.utep.edu/hsi/ (accessed May 15, 2020).
[28] C. L. Dym, A. M. Agogino, O. Eris, D. D. Frey, and L. J. Leifer, “Engineering Design Thinking, Teaching, and Learning,” *Journal of Engineering Education*, vol. 94, no. 1, pp. 103–120, 2005, doi: 10.1002/j.2168-9830.2005.tb00832.x.
[29] L. Mann and S. Daly, “Design Research and Design Practice: A Framework For Future Investigations,” 2009.
[30] R. Razzouk and V. Shute, “What Is Design Thinking and Why Is It Important?,” *Review of Educational Research*, vol. 82, no. 3, pp. 330–348, Sep. 2012, doi: 10.3102/0034654312457429.
[31] M. R. Kendall, A. Coso Strong, I. Basalo, and G. Henderson, “Exploring Faculty Perceptions of Students’ Characteristics at Hispanic-serving Institutions,” presented at the 2019 CoNECD - The Collaborative Network for Engineering and Computing Diversity, Crystal City, Virginia, 2019. Accessed: Apr. 28, 2019. [Online]. Available: https://www.asee.org/public/conferences/148/papers/24997/view
[32] A.-M. Núñez, G. Crisp, and D. Elizondo, “Mapping Hispanic-Serving Institutions: A Typology of Institutional Diversity,” *The Journal of Higher Education*, vol. 87, no. 1, pp. 55–83, Jan. 2016, doi: 10.1080/00221546.2016.11777394.
[33] J. D. Stolk and R. Martello, “Reimagining and Empowering the Design of Projects: A Project-Based Learning Goals Framework,” presented at the FIE, San Jose, CA, 2018. Accessed: May 15, 2020. [Online]. Available: https://www.computer.org/csdl/proceedings-article/fie/2018/08658981/18j9mTgfjxe
[34] D. A. McConnell, L. Chapman, C. D. Czajka, J. P. Jones, K. D. Ryker, and J. Wiggen, “Instructional Utility and Learning Efficacy of Common Active Learning Strategies,” *Journal of Geoscience Education; Bellingham*, vol. 65, no. 4, pp. 604–625, Nov. 2017, doi: http://dx.doi.org/10.5408/17-249.1.
[35] M. Borrego, E. P. Douglas, and C. T. Amelink, “Quantitative, Qualitative, and Mixed Research Methods in Engineering Education,” *Journal of Engineering Education*, vol. 98, no. 1, pp. 53–66, 2009, doi: 10.1002/j.2168-9830.2009.tb01005.x.
[36] J. P. Martin and C. Garza, “Centering the Marginalized Student’s Voice Through Autoethnography: Implications for Engineering Education Research,” *Studies in Engineering Education*, vol. 1, no. 1, p. 1, May 2020, doi: 10.21061/see.1.
[37] A. Q. Gates, P. J. Teller, A. Bernat, N. Delgado, and C. K. Della-Piana, “Expanding Participation in Undergraduate Research Using the Affinity Group Model*,” *Journal of Engineering Education*, vol. 88, no. 4, pp. 409–414, 1999, doi: https://doi.org/10.1002/j.2168-9830.1999.tb00467.x.
[38] B. F. Skinner, *Science And Human Behavior*. Simon and Schuster, 1965.
[39] P. A. Mabrouk and K. Peters, “Student Perspectives on Undergraduate Research (UR) Experiences in Chemistry and Biology,” p. 20.
[40] P. Subban, “Differentiated Instruction: A Research Basis,” *International Education Journal*, vol. 7, no. 7, pp. 935–947, 2006.

[41] E. Schaps, M. Watson, and C. Lewis, "A Key Condition for Character Development: Building a Sense of Community in School," *Social Studies Review*, vol. 37, no. 1, pp. 85–90, 1997.

[42] B. N. Frisby and M. M. Martin, "Instructor–Student and Student–Student Rapport in the Classroom," *Communication Education*, vol. 59, no. 2, pp. 146–164, Apr. 2010, doi: 10.1080/03634520903564362.

[43] J. A. Mejia, R. A. Revelo, I. Villanueva, and J. Mejia, "Critical Theoretical Frameworks in Engineering Education: An Anti-Deficit and Liberative Approach," vol. 8, no. 4, p. 158, 2018, doi: doi:10.3390/educsci8040158.

[44] L. Haerens, N. Aelterman, M. Vansteenkiste, B. Soenens, and S. Van Petegem, "Do perceived autonomy-supportive and controlling teaching relate to physical education students' motivational experiences through unique pathways? Distinguishing between the bright and dark side of motivation," *Psychology of Sport and Exercise*, vol. 16, pp. 26–36, Mar. 2015, doi: 10.1016/j.psychsport.2014.08.013.

[45] M. Vansteenkiste and R. M. Ryan, "On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle," *Journal of Psychotherapy Integration*, vol. 23, no. 3, pp. 263–280, 2013, doi: 10.1037/a0032359.

[46] H. Jang, J. Reeve, and M. Halusic, "A New Autonomy-Supportive Way of Teaching That Increases Conceptual Learning: Teaching in Students' Preferred Ways," *The Journal of Experimental Education*, vol. 84, no. 4, pp. 686–701, Oct. 2016, doi: 10.1080/00220973.2015.1083522.

[47] A. K. Goodboy and S. A. Myers, "The Effect of Teacher Confirmation on Student Communication and Learning Outcomes," *Communication Education*, vol. 57, no. 2, pp. 153–179, Apr. 2008, doi: 10.1080/03634520701787777.