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Leveling the Playing Field: Enacting Equitable Pedagogy to Teach Rigid Body Dynamics

Dr. Eleazar Marquez, The University of Texas, Rio Grande Valley

Dr. Marquez is a Lecturer in the Department of Mechanical Engineering at The University of Texas Rio Grande Valley. His research efforts focus on dynamics and vibrations of mechanical systems under various loads. The mathematical models developed include deterministic and stochastic differential equations that incorporate finite element methods. Additionally, Dr. Marquez research efforts focus on developing and implementing pedagogical methods in engineering education.

Dr. Samuel Garcia, The University of Texas, Rio Grande Valley

Dr. Samuel García Jr. serves as an Educator Professional Development Specialist at Kennedy Space Center. Prior to his position at Kennedy Space Center, Dr. García worked at NASA's Jet Propulsion Laboratory in Pasadena, CA. As an education specialist, Dr. García is deeply committed to developing STEM educational mindsets, tools, and resources and facilitate educational experiences for educators and students. Prior to working as an education specialist, Dr. García served as secondary school educator in Rio Grande Valley in Texas for seven years. Dr. García, a first-generation college student, earned both his bachelor's and master's degrees from the University of Texas Río Grande Valley, formerly University of Texas Rio Grande Valley. He also holds a doctorate degree in School Improvement from Texas State University.

Leveling the Playing Field: Enacting Equitable Pedagogy to Teach Rigid Body Dynamics

Research examining the quality of engineering programs across different instructions of learning has revealed that no two programs are alike. Each program has unique and distinctive features that influence the quality and rigor of education that students receive. Institutional culture, leadership, faculty preparedness, funding and many other factors influence program quality. Additionally, researchers have also noted that many institutional gaps and equity related issues are persistent and troublesome facets that further exacerbate the academic gaps in STEM education. It is within this context, that students attending top tier universities will likely have remarkedly vast academic experiences in terms of level of rigor and quality of education when compared to their counterparts enrolled in minority serving institutions. In this study, a mechanical engineering faculty previously employed at a tier-one private research institution, taught a Rigid Body Dynamics course in a minority-serving institution with the same rigor but with a different pedagogical approach. The objective was to implement equity teaching and expose underrepresented students to the rigorous vector approach, which is only taught at a very few top tier-one institutions across the country and involves having a sound understanding of vector calculus and linear algebra. Given the students' mathematical background, the faculty member decided to implement an inclusive teaching methodology by working out step-by-step examples as a collaborative effort with students to adopt the rigor of the course. The structure of the class was as followed: introduction, inquire, theory, and examples. A self-developed, open-ended survey was conducted to a total of 44 students enrolled in the engineering course. Results indicate that solving examples during class provided a foundation to fully understand the theoretical aspects of the course and allowed assignments to be completed with much ease. Students also mentioned that the rigor of the course was nothing they had experienced before, but given the pedagogical strategy implemented of solving step-by-step examples, it was to easier to appreciate the intricate details of a vectorial approach. Others felt valued by being treated as students in top tier institutions, while a few mentioned the rigor of the course is needed to ensure the quality of education.

I. BACKGROUND AND MOTIVATION

Teaching and Racial Gaps

Student achievement in secondary and higher education is linked to various academic and socioeconomic factors such as teaching, racial gap, school sector, school climate, and family background. Studies conducted by Murnane, Summers, and Wolf indicate that teacher characteristics play an important role in student learning and achievement [23], [24]. To this end, it was reported that a common denominator in high performing schools attributed to consistent, effective teaching [25], [26]. Brimer *et al.* and Madaus *et al.* further concluded that student achievement measures established by institutions are met when instructors alienate their teaching with such standards [3], [18]. However, racial gaps remain a critical component in academic achievement. Camburn, Jencks *et al.*, and Miller reported that test scores for Black and Hispanic students are relatively low compared to Asians and White students, even for those minorities enrolled in selective institutions [6], [9]. In this regard, Vargas *et al*. reported the retention rates from Texas Public University (Table 1), which demonstrate that schools with a large number of minority students have a lower retention rate [28], [29].

Table 1. Texas Public Universities Freshman Retention Rates. Freshman entering in Fall 2015 through Fall 2018 [28], [29].

Texas Public University	Average Freshman Retention Rate
UT Austin	95%
Texas A&M University	92%
UT Dallas	88%
University of Houston	85%
Texas Tech University	85%
University of North Texas	79%
Texas State University	77%
Texas Woman's University	76%
Sam Houston State University	76%
UT Rio Grande Valley	75%
UT El Paso	74%
UT San Antonio	73%
UT Arlington	72%
Texas A&M Kingsville	68%
Texas A&M Commerce	66%
UT Tyler	64%
Texas A&M Corpus Christy	58%
Texas Southern University	54%

Vargas *et al*. further compared the retention rates between the College of Engineering and Computer Science and the institution (UTRGV). It was observed that retention rates of both groups dropped significantly from the Fall 2015 through the Fall 2020 (Table 2).

Table 2. UTRGV College of Engineering and Computer Science First Year Full Time Freshman 1st Year Retention Rate [28], [29]

Cohort	Retention Within College	Retention Within University
Fall 2015	62.3%	78.2%
Fall 2016	66.6%	77.0%
Fall 2017	64.7%	74.9%
Fall 2018	69.4%	78.5%
Fall 2019	67.2%	79.0%
Fall 2020	53.3%	60.9%

School Sector

Studies also reveal that the school sector, particularly the economic facet of the institution, is an indicator of student achievement. In this regard, Bryk *et al.* concluded that the quantity allocated per-pupil expenditure was thoroughly associated with student achievement [4], [5]. Those institutions investing more per student observed higher performance and retention than those institutions allocating minimal resources. Bryk *et al.* further reported that schools investing larger amounts of capital per-pupil had a minimal social class gap and experienced less socioeconomic challenges [4], [5].

School Climate

According to the literature, student achievement is further linked to the school size, climate, and collective efficacy [16], [17]. For instance, Hoy and Tarter reported higher achievement rates from institutions who significantly emphasized on academics and faculty trust [8]. Lee and Loeb reported higher achievement levels and higher retention patterns in smaller institutions [13], [14], [15]. Further, it has been observed that institutions with higher standards of collective responsibility for learning experience higher student performance rates. However, according to Bidwell and Kasarda, achievement is also affected by policies occurring at distinct levels of the school system such as the district, state, and federal mandates and decisions [2].

Family Background

Family background is an additional factor associated with student achievement. Coleman *et al.* reported that more than 20% of student success is tied to the family. Konstantopoulos and Borman specifically reported that family size, structure, and socioeconomic status are variables that influence academic outcomes. Fischer *et al*., Kao *et al*., Mare, and Karen specifically reported the socioeconomic status of parents as a critical element in graduation rates [7], [10], [11], [19]. Alon concluded that college drop-out rates remain elevated given that low-income students have to work while attending school [1]. Vargas *et al*. reported that approximately 60% of the student population at The University of Texas Rio Grande Valley (UTRGV), which is a Hispanic-Serving-Institution, commute to school and cannot afford to live on-campus, while 84.6% of the population receives financial assistance from the school [28], [29].

Table 3. Social and Economic Factors of the Rio Grande Valley

Social and Economic Factors	RGV	Texas	United States
Children Eligible for Free/Reduced Price Lunch	85.26%	58.94%	52.61%
Population Below 200% of Federal Poverty Level	59.85%	37.22%	33.61%
Children Below 200% of Federal Poverty Level	70.56%	48.22%	43.29%
Population with Bachelor's Degree or Higher	16.67%	28.10%	30.32%
Population with Associate's Degree or Higher	21.73%	34.89%	38.49%
Income - Per Capita Income	$15,142.00	$27,828.00	$29,829.00
Per Capita Income by Hispanic/Latino	$13,512.00	$16,640.00	$17,323.00
Per Capita Income by Non-Hispanic/Latino	$31,602.00	$34,871.00	$32,450.00

In this regard, the UTRGV region consists of four counties (Cameron, Hidalgo, Starr, and Willacy), which have concerning statistical measures (Table 3). These statistical measures, which were significantly below the national average, include high concentration of poverty rates; low educational attainment and standards; and limited access to quality educational resources and programs. On the other hand, Lareau *et al*. concluded that college-educated parents play a pivotal role by sharing personal college experiences and giving advice regarding academic resources [12].

II. PURPOSE OF RESEARCH

In this study, a mechanical engineering faculty previously employed at a tier-one private research institution, taught a Rigid Body Dynamics course at UTRGV, a Hispanic-Serving Institution (HIS), with the same rigor but with a different pedagogical approach. The objective was to implement equity teaching and expose underrepresented students to the rigorous vector approach, which is an approach taught at a very few top tier-one institutions across the country and involves having a sound understanding of vector calculus and linear algebra. Given the students' mathematical background, the faculty member decided to implement an inclusive teaching methodology by working out step-by-step examples as a collaborative effort with students to adopt the rigor of the course.

This strategy was incorporated based on one of the strategies from the CIRE model (acronym for Communication, Initiation, Reduction, and Extension) developed by Marquez and Garcia in 2020 at the outbreak of COVID-19 [20], [21]. The model (Figure 1) was initially incorporated as a pedagogical strategy to address academic challenges associated with remote instruction and learning [20], [21]. In a distinct study by Marquez and Garcia, two strategies (Initiation and Reduction) of the CIRE model were modified. The Initiation strategy was modified to perform step-by-step examples during lecture sessions to strengthen the intuitive nature of solving engineering problems [20], [21]. It was reported that students were highly satisfied with the implementation and modification of the practical strategies.

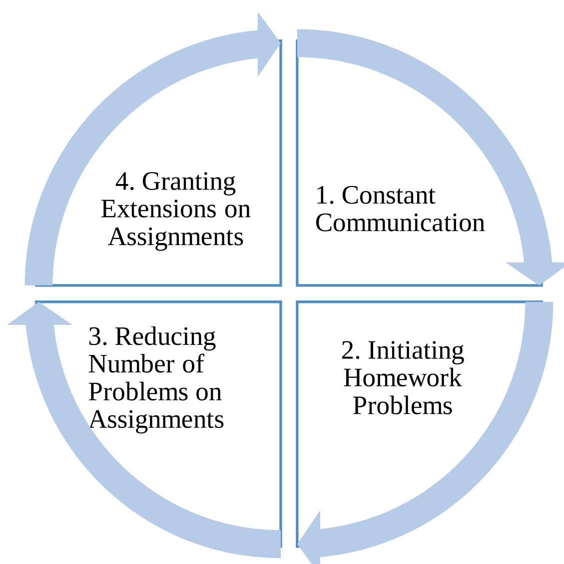

Figure 1. CIRE Model: Introduced in 2020

The pedagogical strategies of the CIRE model are summarized:

Strategies of CIRE Model Developed in 2020 [21]

Strategy 1 – Constant Communication

Constant communication was established with students to understand lecture format, assignment policies, office hours, and grades. In this regard, the instructor utilized two platforms to communicate, 1) email, and 2) CANVAS portal. Emails were sent twice a week regarding announcements related to lectures or assignments, while lecture material was posted weekly on CANVAS.

Strategy 2 – Initiating Homework Problems

The instructor decided to initiate homework problems during lecture session with the intention of supplementing the lack of access to campus resources during the period of remote instruction. Initiating homework problems was intended to supplement office hours, the inability for study groups to meet, and the lack of learning assistance resource.

Strategy 3 – Reducing the Number of Problems on Assignments

Reducing the number of problems on homework assignments and exams was an additional strategy implemented in the CIRE model. Since every course transitioned at once to an online delivery format, the instructor decided – without sacrificing the rigor of the course – to alleviate student workload by reducing the number of problems on assignments. Generally, a total of eight problems were assigned on each homework set prior to the outbreak of COVID-19. This number was reduced in half during the period of remote instruction.

Strategy 4 – Granting Extensions

Given the personal and academic challenges associated with remote instruction, the instructor allowed extensions on assignments. A large percentage of students experienced well-being concerns, family distress, internet issues, and/or challenges completing assignments.

II.1 Focus of Paper

In this paper, however, only Strategy 2 of the CIRE model was incorporated as part of the pedagogical approach for both institutions. Nonetheless, rather than initiating homework problems during lecture sessions, the instructor implemented step-by-step examples after each theoretical concept was covered to strengthen the intuitive nature of solving technical problems [21]. The objective of implementing step-by-step examples was to reinforce fundamental engineering principles in Rigid Body Dynamics such as:

- Linear/angular motion of particles and rigid bodies
- Vectors (direction)
- Geometric relationships
- Equations of motion
- Momentum/rotational inertia.

Leveling the Playing Field

The pedagogical method implemented during lecture sessions for both institutions followed a similar instructional pattern (Figure 2), which included 1) Introduction, 2) Inquire, 3) Theory, and 4) Examples. However, the pedagogical strategy for the tier-one institution varied slightly from the one implemented at the minority serving institution when teaching Rigid Body Dynamics, particularly, when performing step-by-step examples.

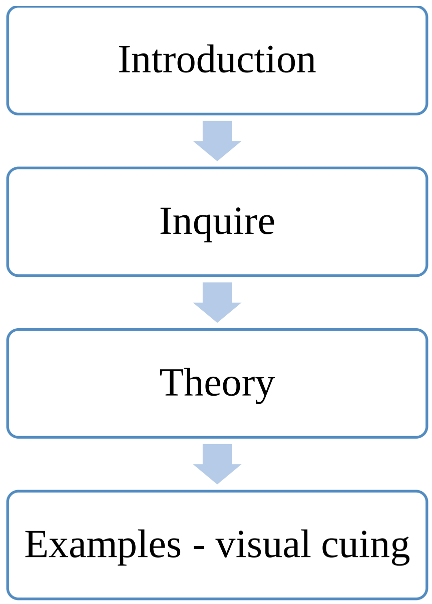

Figure 2. Class Structure for Tier-one and HSI Institutions

II.2 Pedagogy at Tier-one Institution

The pedagogical approach implemented at the tier-one institution was as follows:

1. *Introduction* – lecture sessions were initiated by introducing the respective theme of interest and highlighting related real-world engineering applications. The idea behind emphasizing real-world applications was to acquaint students with a plethora of scenarios in which technical themes are integrated. At times, various physical models were taken to class to further illustrate specific details of real-world applications such as geometric configurations or different types of motion.

2. *Inquire* – following the introductory segment of the lecture, the instructor would pose non-intuitive questions regarding the theme of interest as a strategic mechanism to engage students and ignite technical curiosity.

3. *Theory* – theoretical concepts were then introduced. Mathematical equations were derived and explained in detail. For the vector approach taken in the course, the instructor would sporadically spotlight concepts from Vector Calculus and Physics to enhance the nature of mathematical equations.

4. *Examples* – a few examples were briefly covered in class after the theoretical content of a specific theme was finalized. Covering theoretical concepts for a specific theme generally ranged for a period of two weeks non-interrupted. Then, one class day was utilized to conduct example problems.

II.3 Pedagogy at Hispanic Serving Institution

The pedagogical approach implemented at the HSI was as follows:

1. *Introduction* – lecture sessions were initiated by introducing the respective theme of interest and highlighting related real-world engineering applications. The idea behind emphasizing real-world applications was to acquaint students with a plethora of scenarios in which technical themes are integrated. For each lecture, physical models were taken to class to further illustrate specific details of real-world applications such as geometric configurations or different types of motion. Specifically, three-dimensional physical models such as a crane, excavator, robotic arm, reference frame, and a swing representation were demonstrated to illustrate geometrical and technical concepts traditionally challenging to visualize.

2. *Inquire* – following the introductory segment of the lecture, the instructor would pose non-intuitive questions regarding the theme of interest as a strategic mechanism to engage students and ignite technical curiosity.

3. *Theory* – theoretical concepts were then introduced. Mathematical equations were derived and explained in detail. For the vector approach taken in the course, the instructor would frequently spotlight concepts from Vector Calculus and Physics to enhance the nature of mathematical equations. Most students experienced challenges with these mathematical concepts. As a result, the instructor allotted class time to review basic geometric concepts, trigonometric identities, derivatives, integrals, and mathematical operations such as dot-product and cross-product between vectors.

4. *Examples* – step-by-step examples were covered in detail during lecture sessions after the theoretical content of a specific theme was finalized. Since theoretical concepts were challenging to understand at times, the instructor performed step-by-step examples every other day. To further enhance student understanding, collective learning and active participation were targeted during the process of solving problems. The aim was to stimulate a healthy environment and promote diverse modes of inquiry. Most example problems solved during lecture sessions involved using the three-dimensional physical models (crane, excavator, robotic arm, etc.) demonstrated in the introductory segment.

III. METHODS AND ANALYSIS

In this research study, students enrolled in a Rigid Body Dynamics course were surveyed to better understand gather insights into the pedagogical approaches utilized to engage and enhance student learning. The study sought to examine students' experiences related to the instructional methods that were applied to increase student understanding of engineering related concepts. The sample selection consisted of 44 undergraduate students enrolled at a public Hispanic Serving Institution in Texas. The demographics of the student populated surveyed consisted of 68% male and 32% female, of which 95% are Hispanic/Latino. The authors employed a qualitative research design, and the primary method of data collection was a self-developed survey instrument consisting of a total five open-ended questions. The process for developing the survey items consisted of questions that sought to examine instructional and pedagogical strategies implemented to teach students rigorous engineering concepts based on students' experiences in the course. As such, the questions provided students the opportunity to delineate, reflect, and share valuable insight and experiences that can help develop and refine effective and equitable engineering pedagogy.

The data analysis consisted of an open coding technique to organize data into categories. According to Creswell (2007), open coding "involves taking data and segmenting them into categories of information" (p. 239-240). While all the data gathered from the survey provided useful information, the open coding process was repeated multiple times to slowly reduce the number of categories that became the major themes for each. Below, we highlight the results of each question which help provide important insight into the approaches used to facilitate student learning.

Emerging Themes Identified in Study

Several themes emerged from the open-coding approach utilized in the study. The open-coding technique consisted of the both the authors facilitating an initial review of participant responses for themes. The authors then employed axial coding, which assisted in the formulation of broader themes and categories. This step helped to draw connections between the data and codes developed in the analysis by establishing categories that served as the basis for the themes identified in the study. Each of the survey items and corresponding student responses were analyzed and coded for emergent themes. Table 1 illustrates the survey items along with their respective emergent theme.

Table 1. Survey Questions and Corresponding Themes

Survey Questions	Themes
Question 1: Do you find it useful for the professor to solves examples in class?	Examples are Essential to Learning New Concepts
Question 2: What do you think about the examples solved in class collectively as group?	Effectiveness of Peer Collaboration and Engagement
Question 3: What is your opinion on the instructor using visual supplements when solving problems?	Increased Understanding and Confidence
Question 4: What do you think about the rigor of this course compared to others?	Embracing the Challenge and Valuing Rigor
Question 5: What did this class teach you about Engineering?	Increased Knowledge of Dynamic Nature of Engineering

Collectively, the themes that emerged in the study provide insight into students' experiences with the approaches and technique implemented by the instructor. This data reveals that importance of incorporating pedagogical strategies that consider learning contexts, students' backgrounds, and institutional resources.

Limitations of Study

The authors identified the following limitations of the study: small sample size; replicability of the study is limited to engineering students; data collection was limited to surveys; and study was limited to students enrolled in one university.

IV. RESULTS & DISSCUSSION

IV.1 Results from HSI Students

Question 1: *Do you find it useful for the professor to solves examples in class?*

Question 1 asked students if they found value in the professor's decision to solve examples in class. The students in the study unanimously approved the instructor's approach of solving problems in class which greatly aided in understanding the material and clear up any existing or potential confusion. Below are a few of the responses that provide additional information:

Examples are Essential to Learning New Concepts

> *"It is super useful. The way Dr. X breaks down problems is very educating and helpful. Additionally, they help to understand the proper steps and techniques in order to tackle problems."*

> *"Yes, it helps me understand how to apply the theories and gives an understanding when he explains the mechanisms. It makes me check that I'm not only solving a problem using the topics but also checking that the answers make sense."*

> *"Yes, as it demonstrates how the pieces of the process work in specific scenario. It seems like an aid to have seen the instructor do it first, then practice alone already knowing the steps."*

> *"I find this to be one of the most useful things to be able to succeed in this class. Examples are well developed, and he explains them thoroughly."*

As indicated by the responses above, the students overwhelmingly found the collective problem-solving technique employed by the professor extremely useful and relevant in understanding and making sense of the material.

Question 2: *What do you think about the examples solved in class collectively as group?*

In addition to solving mathematics and physics questions in class, the professor also utilized a collective approach by engaging students in the process and collectively attempting to figure out solutions to the questions being presented. Below are a select few of the responses that provide additional information into how this method helped the students learn more effectively:

Effectiveness of Peer Collaboration and Engagement

> *"It would help us all find the solution using the same process of thinking rather than everyone getting the same answer yet not knowing how exactly to get there. Collectively, we'd all learn the material together and if someone doesn't understand then their peers would be able to explain it to them."*

“Dr. X allowing class involvement gets more students engaged. This in return allows students to gage what is happening rather than following a process.”

“I think they are important in giving students the chance to practice both guided and unguided examples. The pace of the examples is a good pace where students have time to think about where things are derived from as well as it is fast enough so that attention or interest is not lost.”

“If the student may be shy to ask a question no doubt that another one can have the same question and ask the professor for assistance which in the end answer the question for the first student.”

“It's very beneficial because sometimes I am lost on where to start. By writing on the board the formulas and important known info it gives me a stronger foundation and helps me note where I can improve in the problem-solving process.”

The responses above illustrate students’ experiences with the collective problem-solving approach employed by the instructor. Many of the students articulated how this method helped them understand course material. This approach was much more engaging than traditional, didactic methods commonly used to teach engineering concepts. Furthermore, as indicated by existing research, pedagogical approaches that engage student participation help improve levels of student achievement, retention, and success, most notably those from traditionally underserved and underrepresented communities.

Question 3: *What is your opinion on the instructor using visual supplements when solving problems?*

The third question sought to gather students’ thoughts about the incorporation of visual supplements to solve problems.

Increased Understanding and Confidence

“It helps me a lot since I am a visual learner. The usage of visual supplements makes the class less boring since looking at these supplements catch more my attention than just hear talk and talk.”

“The visual supplements are very nice. The crane example is good, because its intuitive to imagine that a hanging weight will behave in a way that is difficult to determine mathematically, yet also intuitive to our sense of motion.”

“Visual supplements help me tremendously. For example, reference frames using three markers and sticks to join them together to form a three-dimensional axis. Cranes helped me understand the motions of various components and selecting the proper body to analyze. Robots are similar, all while learning the program runs in the robot and you need dynamics to write that program.”

“Personally, it really helps understand what we’re learning otherwise I’m just memorizing terms and formulas but now when I’m solving a problem, I can visualize it in my head operating and can understand how I’m going about the problem.”

Student comments above reflect their thoughts about the utilization of visuals by the instructor to solve problems during class. All the students surveyed firmly believe that the use of visuals greatly added to their understanding of concepts being taught. As indicated above, the use of visuals helped them better visualize concepts and make real world connections to the course material. It was also much more engaging and visually appealing which accommodates to students' diverse learning needs.

Question 4: *What do you think about the rigor of this course compared to others?*

As previously mentioned, a goal of this course was to expose underrepresented students to the rigorous vector approach, which is only taught at a very few top tier-one institutions across the country and involves having a sound understanding of vector calculus and linear algebra. As such, the rigor of the course was intense, and therefore challenged students' academic skills and abilities. Question Four sought to gather insights into how this course compared with similar courses they have taken. Below are a select few of the responses:

Embracing the Challenge and Valuing Rigor

> *"This course is tough compared to the other engineering courses I have taken. I actually had to study a lot and pay attention in class because this isn't one of those classes where you can learn all the material in a few hours before the exam."*

> *"This class was one of the most rigorous classes I have taken from my 4 semesters in college. It is a tough class the learn, but Dr. X does a great job in explaining the class. Although sometimes I felt like quitting, it really isn't possible if one puts the time and effort to learn it."*

> *"I definitely think this is one of the more challenging courses. I had never seen anything quite like it. Other courses are very plain and generalized and dynamics was the entire opposite. The theory behind the formulas was proven in class, and no formulas were simply memorized, we learnt every step in solving the problems."*

> *"This course became more rigorous as the class went on, building on top of itself with every topic. At the end, it does seem like a lot, but if you have been paying attention in the class, then you should be able to succeed."*

> *"It is challenging, but once you able to figure it out you feel accomplished. This course required you to put more time into really understanding the concept because there was no way around it."*

As evidence from the data collected from the survey, the majority students noted that course rigor was high and challenged them in ways that other courses had not. The course was designed to incrementally increase in rigor over the duration of the semester, while offering pedagogical supports and scaffolding during this process. Despite the increase in rigor, the students also noted that excelling in class was possible due to the methods the instructor employed and by committing to learning the material. The increased level of expectations challenged students and therefore motivated them to study hard and learn the material. This in turn created a level of confidence and accomplishment after completing the course.

Question 5: *What did this class teach you about Engineering?*

The last survey item administered to the students centered on soliciting information regarding knowledge attained about engineering in general. Below are a few student comments that help provide a detailed view regarding this question:

Increased Knowledge of Dynamic Nature of Engineering

> *"This class thought me about not having to follow a specific route to solve a problem, and solving the problem based on my reference frames. This is helpful in studying multiple types of problems."*

> *"This class is the first to truly introduce me to engineering applications. It gave me an idea of the kind of math and problem solving that can take place in engineering jobs. My perspective on engineering improved because we began to use the skills, we've been learning all along in our major, and it all made sense how it ties in together in the end. "*

> *"It taught me that engineering can be not all that hands on and more mathematical or theoretical in way, which I like in part as I've never been all that sold on the hands-on general perspective of engineering. I think my perspective changed in a sense that I realized that engineering had broad spectrum of opportunities not only in terms or majors and concentrations but also in future prospective jobs and the different tasks one can do as an engineer."*

> *"This class taught me that while engineering can be a rocky process to trend on, with the right instructor and amazing lectures, engineering can be very fun and interesting to pursue in. My perspective did change, as a majority of my previous engineering courses have been very dull and straight-forward. This class has allowed me to see engineering in a very fun, challenging and rewarding way."*

The students noted that the course helped them gain a deeper level of understanding of dynamic nature of engineering, develop useful skills and approaches to problem-solving, and other potential career opportunities in engineering related fields.

IV.2 Previous Results from Tier-one Institution [20], [22]

Student responses from the tier-one institution resonated with those from the HSI responses. As such, it was mentioned that the strategy of working step-by-step problems during class, significantly encouraged understanding of theoretical concepts and their related applications.

> *"I thought this was really beneficial since oftentimes professors give students the theory but do not really show how to apply it in different examples. This was probably my favorite part about lecture since we got to apply the knowledge, we had previously learned right then and there."*

> *"This was a great approach for the harder problems since it gave a foundation for us, additionally the purpose of homework is to prepare for exams and practice*

concepts that we will be applying as engineers. Therefore, it is more important to know how to solve a problem than to waste too much time trying to figure it out with no progress. Personally, the way I learn better is by seeing an example then by repetition of other problems like it so this approach was great."

Students in the tier-one institution further indicated that the integration of physical models provided opportunities to engage with peers and help promote technical skills sets [22]. These results also resonated with HSI students.

"It's like a different experience from my background because physics 101 and 102 here is mostly that you learn the concepts in class and then you kind of have to go to discussion or somewhere else to actually how to apply them but it's like really helpful when Dr. Z uses example problems in class and actually shows you how to apply the things he's learning in class. I think that that really helped my confidence level because instead of just trying to figure it out a little bit blindly, it's like everything that we do builds on...like he always says we have the tools and he's not wrong."

"I really like examples like that have some real-world applications, even if it's just a picture. like thing I think of specifically is when you have pliers and it's just a static system and it's gripping something and what I never really thought about is that there is the force of the hand, there's the force of what you're grabbing but there's also a force on the pin. But when you think about it now it's like oh of course there's a force on the pin, it's touching something while something is trying to move against it but just examples like that show you how you like 1. How you can apply it to your life; and 2. It helps you understand how to approach it."

Further, 90% of the students surveyed in the tier-one institution strongly agreed or agreed that the visual supplements helped link between theory and practice, while 87% strongly agreed or agreed that the instructor utilized the visual tools to further emphasize external design consideration on a system (Table 2) [22].

Table 2. Student Responses Percentages from Tier-one Institution [22]

Question	N	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
I prefer to have visuals when learning new material.	53	47.17% (25)	45.28 % (24)	7.55 % (4)	0.00 %	0.00 %
The visualization tools provided in this course were helpful in understanding specific engineering concepts.	53	35.85 % (19)	50.94 % (27)	13.21 % (7)	0.00 %	0.00 %
The visual aid tools helped me correlate between theory and real-world applications.	53	35.85 % (19)	54.72 % (29)	9.43 % (5)	0.00 %	0.00 %

The instructor utilized the visual tools to emphasize possible design consideration on a structure or mechanism.	53	35.85 % (19)	50.94 % (27)	13.21 % (7)	0.00 %	0.00 %

V. CONCLUSION

As evidenced by research, there is a great demand placed on institutions of higher education to adequately educate, prepare, and train young engineering professionals to enter the workforce. Researchers speculate that there the engineering industry will face considerable shortages of trained professionals to fill the number of growing jobs in this dynamic and complex field. Within this context, there is increased necessity for educational institutions to develop strategies that proactively, equitably, and effectively engage students from underrepresented and underserved communities. As such, it is of great importance for university officials, leaders, and faculty to create and implement processes to recruit, retain, and graduate students of color in engineering related fields.

In this study, the authors examined the experiences of students enrolled in an engineering course at a Hispanic Serving Institution in deep South Texas. During the course, the instructor utilized various pedagogical instructional approaches to expose underrepresented students to the rigorous vector approach, which is only taught at a very few top tier-one institutions across the country and involves having a sound understanding of vector calculus and linear algebra. Keenly aware of the disparity of rigor and quality of learning between top-tier research institutions and emerging institutions, the faculty member decided to implement an inclusive teaching methodology by working out step-by-step examples as a collaborative effort with students to adopt the rigor of the course.

The pedagogical method implemented during lecture sessions for both institutions followed a similar instructional pattern which included 1) Introduction, 2) Inquire, 3) Theory, and 4) Examples. However, the pedagogical strategy for the tier-one institution varied slightly from the one implemented at the minority serving institution when teaching Rigid Body Dynamics, particularly, when performing step-by-step examples. To further enhance student understanding, collective learning and active participation were targeted during the process of solving problems, which was not implemented at the tier-one institution. The aim was to stimulate a healthy environment and promote diverse modes of inquiry. Results indicate that solving step-by-step examples during class provided a foundation to fully understand the theoretical aspects of the course and allowed assignments to be completed with much ease. Students also mentioned that the rigor of the course was nothing they had experienced before, but given the pedagogical strategy implemented of solving step-by-step examples, it was easier to appreciate the intricate details of a vectorial approach. The use of visual supplements and collective approach to working out problems in class greatly improved their ability to comprehend course material. Moreover, the students gained a stronger understanding of engineering in general, while developing self-confidence needed to excel in engineering related fields. Others felt valued by being treated as students in top tier institutions, while a few mentioned the rigor of the course is needed to ensure the quality of education. These results were also reflected in student responses from the tier-one institution.

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