Communicating Academic Success: Shaping an Inclusive Learning Environment to Promote Student Engagement in Engineering Education

Eleazar Marquez, Ph.D.
Department of Mechanical Engineering
The University of Texas Rio Grande Valley

Samuel Garcia Jr., Ph.D.
College of Education
Texas State University

Abstract

Classroom environments that involve and encourage active student participation have demonstrated positive impact on student learning, engagement, and overall academic success. Studies reveal that healthy learning environments may further be established by incorporating effective channels of communication which eliminate certain barriers and address factors that limit student participation such as student motivation, self-esteem, and issues relating to student-faculty relationships. This is especially vital for diverse students and those from underserved and underrepresented communities, who often find it difficult to participate and engage in classroom interactions due to feelings of intimidation. In this study, two communication strategies from the recently established pedagogical model ECNQ (acronym for Engage, Communicate, Names, and Questions) were implemented in an effort to address contemporary learning challenges in engineering education. Specifically, encouraging student participation and inquiring questions were the [model] strategies recurringly implemented when solving step-by-step example problems during lecture sessions. Collective learning and active participation during the process of solving problems were targeted amongst students to stimulate a healthy environment and promote diverse modes of inquiry. In this regard, a total of 70 students enrolled in an Engineering Dynamics course participated in a self-developed survey. Results indicate that 98% of the students felt the instructor created a friendly environment conducive to learning, while more than 85% of the participants felt encouraged to participate when solving example problems. Based on the open-ended responses, students gained different perspectives on engineering problems when challenged outside the norm, and thus forced to think outside the box.

Introduction

Student learning, engagement, and success are three academic areas which are positively influenced by climate, tone, or ambiance of a classroom setting [8], [9], [10]. Walberg reported in the 1960s that the socio-emotional climate of the classroom is dependent on two measures: 1) instructor personality, and 2) student academic ability and interest in the subject [1], [16], [17], [18]. Getzels and Thelon further reported that classroom environments are contingent of institutional role-expectations and individually personality dispositions [11].

In 2000, Land and Hannafin revealed that in order student learning, engagement, and success to be the most effective, instructors' should be cognizant of students' needs and background [13]. This learning framework varies from the traditional role of the instructor to simply disseminate knowledge in a given field and depend on the students' academic ability and interest in the subject.

The learner-centered learning management and classroom environment concept is geared towards providing advice, mediating, and learning collectively with students [11], [12]. In this classroom climate, for instance, the collective learning is generated from the instructors' actions such as expressions or teaching methods, as well as the students' actions such as involvement in classroom activities and participation. As such, three components of climate enhancement have been reported in the literature: 1) managing learning activities, 2) encourage participation, and 3) supporting student learning [11]. Research indicates that this concept of instruction is more effective, continuous, and sustainable than the traditional learning management concept [2], [11], [15].

To this end, a model termed ECNQ (e.g., acronym for Engage, Communicate, Names, Questions) was developed and implemented by Marquez and Garcia in 2019 (Figure 1) to disrupt traditional normalized, ineffective teaching practices in engineering education [14]. The model is based on four communication strategies incorporated to create a healthy learning environment, eliminate intimidation barriers, and promote student engagement.

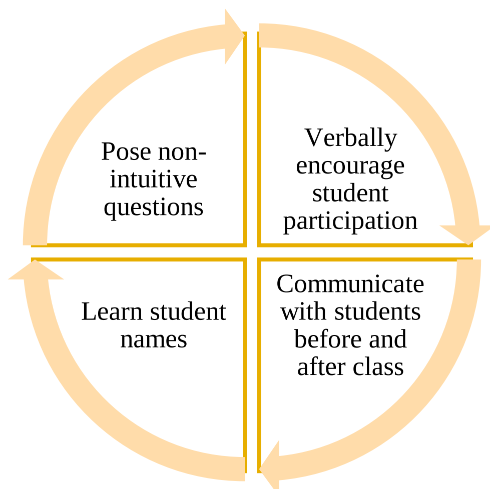


Figure 1. ECNQ Model Introduced in 2019

In the first strategy, faculty members are recommended to verbally encourage student participation during lecture sessions. The second strategy of the model involves communicating with students prior and post lecture sessions and was implemented to eliminate the notion of unapproachability by the instructor. Part of the ECNQ model further involved referencing students by their name during or outside lecture sessions with the intention of promoting educational productivity and strengthen faculty-student rapport. Lastly, a strategic technique of posing non-intuitive question during lecture session was delineated in the communication model in order to engage students and promote participation [14].

Proposed Work

In this study, two communication strategies of the established pedagogical model ECNQ were implemented in an effort to address contemporary learning challenges in engineering education. Specifically, encouraging student participation and non-intuitive inquiry were the [model] strategies recurringly implemented throughout the semester when solving step-by-step example problems during lecture sessions. Collective learning and active participation during the process of solving problems were targeted amongst students to stimulate a healthy environment and promote diverse modes of inquiry. For the first strategy, the instructor initiated the process of encouraging student participation to eliminate barriers of communication. Simultaneously, non-intuitive questions were posed through the process of solving problems with the intention of giving students an opportunity to develop engineering aptitudes, be synthesized to details beyond textbook context, and engage with the instructors' technical expertise [14].

Methods and Analysis

For this study, a mixed-methods research design was utilized to gather students' insights into specific pedagogical techniques designed to create a conducive learning environment and help facilitate active-student engagement and participation. The context of the study was public, Hispanic Serving Institutions in Texas. The authors employed a convenient sampling technique in which a survey was distributed to a total of 70 students enrolled in an Engineering Dynamics course participated in a self-developed survey. The survey instruments consisted of a total of five items, two of which included Likert-Scale responses. The survey collected several open-ended questions which provided students an opportunity to share in detail their views and personal learning experiences.

Due to the amount of student responses generated by the study, the authors employed a thematic approach combined with a data reduction technique to highlight prominent and relevant information. As such, only a select number of responses are presented for each of the survey items administered in the study.

Participants were asked the following discussion questions:

Table 1. Survey Questions

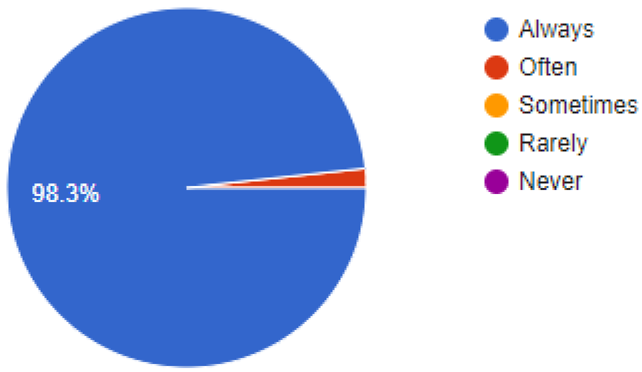
Question 1: I feel the professor creates a friendly environment in class
Question 2: I feel encouraged to participate during class
Question 3: Do you find it useful for the professor to solve examples in class?
Question 4: What do you think about the examples solved in class collectively as a group?
Question 5: What is your opinion about the professor posing non-intuitive questions to spark curiosity on the Dynamics topics discussed in class?

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.

Results

Question 1: I feel the professor creates a friendly environment in class



For question one, a total of five response options were outlined based on a 5-point Likert Scale format with the following coding: 1) always, 2) often, 3) sometimes, 4) rarely, and 5) never.

Results indicated that 98.3% of the surveyed students believed that the instructor created a friendly, cordial learning environment. The remaining students indicated that the instructor often met this goal.

Open-ended responses to Question 1 provided additional student insight into how the instructor was able to create a learning environment conducive to learning.

> *"Dr. X's class is one like that of a classroom comedy sketch (in a positive way). You do not know what to expect however you will laugh and have a new perspective after his lecture (learn in an unconventional way)."*

> *"An extremally good friendly and funny environment. There hasn't been a moment in call where the environment has felt unwelcoming or toxic."*

> *"He calls on every student making them feel part of the class with getting their attention."*

> *"I like the interactive setting and that the Material is not overwhelming due to examples of real-life applications."*

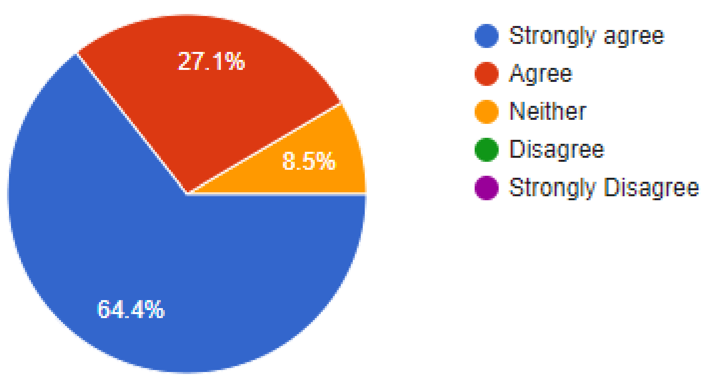
> *"He comes to class talking to us about his weekend or what he did, and it makes me feel more comfortable in class knowing he's willing to share those details with us he just doesn't come in and starts writing stuff on the board."*

> *"I like that he talks loudly, many other engineering professors tend to mumble so I don't understand. The jokes are what makes Dr. Marquez's lectures different from any other professor and teacher I have ever had. Very relatable as well as we are*

both from the same region and have parents who didn't go to college. He also had a similar upbringing as me, so I feel like I belong whenever he is teaching."

As evidenced by the student responses above, the instructor helps create a friendly and effective learning environment by making intentional efforts to connect and relate to the students. The environment seems to be relaxed yet effective in helping students feel comfortable with the content and with peers. The data reveals that students generally appreciate and are receptive to engaging and establishing a personal connection with their instructor. Several characteristics are worth noting: the use of humor, being approachable, an engaging and lively environment, building personal connections, and having similar experiences to the students. Collectively, these characteristics help shape a well-received and respected classroom learning environment.

Question 2: I feel encouraged to participate during class



For question two, a total of five response options were outlined: 1) strongly agree, 2) agree, 3) neither 4) disagree, and 5) strongly disagree. Nearly two-thirds (64.4%) of the students felt encouraged to participate in the class, while 27.1% of the students choose agreed. Only 8.5% of the students surveyed selected neither.

Question 3: Do you find it useful for the professor to solve examples in class?

Question 3 was an opened-ended inquiry that sought to gather student insight into practical approaches utilized by the professor to explain certain concepts. how the instructor was able to create a learning environment conducive to learning. All the students agreed that they found it useful that professor provided examples of how to solve problems in class. Below are a few of the responses that provide additional information:

"In my humble opinion, that is the best way to teach a course that requires a lot of work for each problem. So yes, I find it very useful."

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

> *"I find it very helpful that we're solving the problems together step-by-step to all get the same answer. One issue is that any unfinished problems should be quickly post afterwards so we can quickly move onto the next item the following day instead of receiving homework with problems that we've yet to learn to finish."*
>
> *"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, I have a hard time dealing with formulas when there all variables and no numbers.*
> *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 agreed that reviewing and breaking down problems in class are extremely helpful in understanding and making sense of the material.

Question 4: What do you think about the examples solved in class collectively as a group?

The fourth question expanded on the previous question by inquiring about the collective approach employed by the professor solving problems in class. Nearly all the students found this approach to be beneficial and useful. The results indicate this stance:

> *"I am fond of solving examples collectively as a group, because we all benefit from listening to different ways to approach a question."*
>
> *"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."*
>
> *"If examples were solved collectively as a group, it may help the students develop their own ideas on how the problems will be approached and solved."*
>
> *"It helps as it allows all of us to put our brains together to solve the material we just learned."*
>
> *"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."*

Question 5: What is your opinion about the professor posing non-intuitive questions to spark curiosity on the Dynamics topics discussed in class?

The last survey item administered to the students centered on soliciting information regarding their views about questions designed to stimulate curiosity about Dynamics topics covered in the course.

In the same vein as the previous questions, nearly all responses gathered provided positive remarks or comments. The responses are presented below:

> *"I think this is very good. Like I mentioned before, going to a class and listen 1 hour and 15 minutes to a professor just talk and solve sometimes is boring. The professor making us think outside of the box can be very helpful."*
>
> *"The Professor understands that intuitive questions may be more speculative and perceptive, but the mathematical approach is more discursive, systematic, and logical for learning in engineering. This makes the course more exciting and fun to go to."*
>
> *"My passion for Dynamics is increasing as a function of time! It makes me feel like I can be a very capable engineer by learning dynamics in a nontraditional way at this university."*
> *"This is a great thing to implement as it makes students think outside the box, which I think is an important skill to have as an engineer."*
>
> *"These questions make you think about what is going to be covered in class later on in the semester. For example, considering a pendulum rocking back and forth. What if this pendulum is also moving through let's say in the one direction while rocking back and forth as well."*
>
> *"The application of examples in everyday life makes me more interested that we use Dynamics more than I thought. It even makes me think outside class how Dynamics is applied in objects as simple as a moving fan, closing curtain blinds, or even driving a car."*

The responses provided by the students reveal that the of posing non-intuitive questions to spark curiosity on the Dynamics topics discussed in class is a highly beneficial approach to teaching and learning in the engineering classroom. Based on the responses, one can discern that this technique provides learning opportunities view and engage with the course material in different ways. This encourages students to view multiple perspectives while establishing real-world connections between engineering concepts and general applications. This process further supports and helps meet the diverse learning needs of the students in the class.

Conclusion

In the learner-centered classroom climate, collective learning is generated from the instructors' actions such as expressions or teaching methods, as well as the students' actions such as involvement in classroom activities and participation. In this research study, two communication strategies were implemented in an effort to address contemporary learning challenges surrounding engineering education. Specifically, encouraging student participation and non-intuitive inquiry were recurringly implemented throughout the semester when collectively solving step-by-step example problems during lecture sessions in an Engineering Dynamics course.

Preliminary results indicated that the instructor assisted in creating a friendly and effective learning environment by making intentional efforts to connect and relate to students. According to student comments, the classroom environment seemed relaxed but effective in promoting comfort with course material and with colleagues. To this end, the use of humor, being approachable, an engaging and lively environment, building personal connections, and having similar experiences to the students positively influenced by climate, tone, or ambiance of a classroom setting.

References

[1] Boy, A. V. and Pine, G. J. (1988) *Fostering Psychosocial Development in the Classroom.* Springfield, IL: Charles C. Thomas.

[2] Brophy-Herb, H. E., Lee, R. E., Nievar, M. A., & Stollak, G. (2007). Preschoolers' social competence: Relations to family characteristics, teacher behaviors and classroom climate. Journal of Applied Developmental Psychology, 28, 134–148.

[3] Carnegie, Dale. How to Win Friends and Influence People. New York: Simon & Schuster, 2009. Print.

[4] Chaokiratipong, N., Namfa, B., & Thaithae, C. (2002). Learner-centered learning management. http://www.moe.go.th/wijai/lesson5%20childcenter.pdf

[5] Dorman, J.P 1999, 'The evolution, validation and use of a personal form of the Catholic School Classroom Environment Questionnaire', *Catholic Education,* vol. 3, pp. 141-157.

[6] Dorman, JP 1997, 'Use of student and teacher perceptions to assess classroom environment', *Set,* vol. 1, no. 9, pp. 1-4.

[7] Dorman, J.P 2000, 'Validation and use of a short form of the University-Level Environment Questionnaire', *Queensland Journal of Educational Research,* vol. 16, no. 1, pp. 31-55. http://education.curtin.edu.au/iier/qjer/qjer16/dorman.html

[8] Dorman, J. P. (2002) Classroom environment research: Progress and possibilities. *Queensland Journal of Educational Research,* 18, 112-140.

[9] Fraser, B. J. (1998a) Classroom environment instruments: Development, Validity, and applications. *Learning Environments Research,* 1, 7-33.

[10] Fraser, B. J. (1994) Research on classroom and school climate. In D. Gabel (ed) *Handbook of Research on Science Teaching and Learning* (pp. 493-541). New York: Macmillan.

[11] Kanit Sriklaub, Suwimon Wongwanich, Nonglak Wiratchai, Development of the Classroom Climate Measurement Model, Procedia - Social and Behavioral Sciences, Volume 171, 2015, Pages 1353-1359, ISSN 1877-0428. https://doi.org/10.1016/j.sbspro.2015.01.253.

[12] Khammanee, T. (2004). Teaching sciences: Knowledge for effective instruction. Bangkok: Chulalongkorn University Press.

[13] Land, S. M., & Hannafin, M. J. (2000). Student-centered learning environments. In D. H. Jonassen & S. M. Land, Theoretical foundations of learning environments (pp. 1 -23). Mahwah, NJ: Lawrence Erlbaum Associates.

[14] Marquez, E., Garcia Jr., S. Creating a Learning Environment that Engages Engineering Students in the Classroom via Communication Strategies. *2019 ASEE Annual Conference & Exposition*. June 16-19, Tampa, Fl. Paper ID: 26093.

[15] McCombs, B. L., & Whisler, J. S. (1997). The learner-centered classroom and school strategies for increasing student motivation and achievement. San Francisco, CA: Jossey-Bass Publishers.

[16] Walberg, H.J & Anderson, GJ 1968, 'Classroom climate and individual learning', *Journal of Educational Psychology,* vol. 59, pp. 414 -419.

[17] Walberg, HJ 1976, 'Psychology of learning environments: Behavioral, structural, or perceptual?', *Review of Research in Education,* vol. 4, pp. 142-178.

[18] Walberg, H.J 1991, 'Classroom psychological environment', in K Marjoribanks (Ed.), *The foundations of students' learning* (pp. 255-263), Pergamon, New York.

[19] Vygotsky, L.S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

ELEAZAR MARQUEZ
Dr. Marquez is a Lecturer in the Department of Mechanical Engineering at The University of Texas Rio Grande Valley. His research efforts focus on engineering education, particularly in developing pedagogical and scaffolding techniques that facilitate student learning and foster academic inclusion, development, and post-graduation instruction.

SAMUEL GARCIA JR.
Dr. Samuel Garcia Jr. serves as a NASA Educator Professional Development Specialist at Kennedy Space Center. Dr. Garcia helps facilitate professional development to both form and informal STEM educators utilizing NASA resources with a specific focus on Culturally Responsive Pedagogy. He also works with faculty serving in Minority Serving Institutions in developing STEM educational tools and resources for teachers to implement in their classroom. Dr. Garcia's research agenda is geared towards community and educational change by creating healthy, equitable, and culturally responsive learning environments for traditionally underserved populations.