6-2019

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Eleazar Marquez

Samuel Garcia

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Dr. Eleazar Marquez, Rice University

Eleazar Marquez is an Assistant Teaching Professor in the Department of Mechanical Engineering at Rice University.

Dr. Samuel Garcia Jr., Texas State University

Dr. Samuel García Jr. currently serves as Educator Professional Development Specialist at the Jet Propulsion Laboratory in Pasadena, CA and is an Assistant Professor of Practice for the LBJ Institute for Education and Research at Texas State University.

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In this research effort, the authors claim that possessing technical knowledge is an insufficient asset to establish a learning environment that renders engagement with engineering undergraduate students during lecture sessions, but rather the integration of various communication strategies that support students' academic development. Research has noted that classroom context and conditions impact the degree of student learning and engagement and are further enhanced when students feel comfortable communicating with the instructor and with their peers. If such acquaintance is nonexistent, student participation may be stifled and limited despite the technical concerns arising during lecture sessions. Thus, it is imperative for faculty members to consciously and intentionally foster communication before, during, and after lecture sessions, and become sensitive to such academic needs that will enable students to participate with solvency. In this context, four communication strategies have been identified that eliminate intimidation scenarios and nurture a learning environment to be generated consistently: verbally encourage student participation, learn student names and inquire from them during lecture, have communication with student before and after class, pose non-intuitive question that spark curiosity. The context of this research was a small private university in Texas which utilized a single case study design framework to examine the effects of one faculty members' implementation of the four communication strategies in an undergraduate engineering course. Results indicate that utilizing these strategies minimizes traditional classroom power relations, strengthens student-instructor communication, increases student collaboration, and fosters an active learning environment that enhances student engagement and learning.

I. MOTIVATION AND BACKGROUND

Decades of research in primary, secondary, and higher-education levels has posited that classroom environment, which commonly alludes to the climate, tone, or ambience that influences the setting, has a considerable impact on student learning, engagement, and success [1], [4], [6]. Walberg and Boy *et al.*, for instance, reported that educational productivity is dependent on the psychosocial aspect of the classroom, which combines psychological factors with the surrounding social environment [7], [8], [9], [10]. These prominent results indicate that educators must not only prepare to disseminate content with clarity, structure, and enthusiasm, but should focus simultaneously on creating an environment that engages diverse learning styles and stimulates academic development.

Despite the research endeavors conducted on the laudable effects of classroom environments, and the increased attention it has received by educators and administrators given its immediate and long-term benefits, not every discipline, particularly in higher education, recognizes, or is willing to promote, the impact an environment can have on student learning, engagement, and success. These types of instances are particularly visible in science, technology, engineering, and math (STEM) related disciplines.

The authors in this study postulate that learning environments are notably absent in engineering classrooms given that most faculty members possess research-focused credentials and not formal pedagogical preparation, which is an indispensable instructional component to effectively deliver technical content and nurture student development in higher education. The absence of learning environments can be traced to the structure of existent engineering [graduate] programs which do not enforce a formal pedagogical development through the respective curricula. In numerous circumstances, graduate students, or even post-doctoral fellows, are simply petitioned to conduct recitation sessions with the assumption that their technical knowledge will automatically generate an environment that engages diverse learning styles. However, most of these sessions have minimal success due to the monotonous and ineffective teaching techniques adopted when disseminating content.

Given the absence and the lack of receptivity to formal pedagogical training in engineering disciplines, numerous scholars who attain faculty positions repeatedly struggle with identifying and incorporating instructional techniques that foster learning environments, influence educational outcomes, and tailor student engagement. As such, the authors in this study suggest that classroom participation may be stifled and limited due the normalization of institutional cultural practices that persist in academia and function towards creating learning environments that generate nonexistent acquaintances between the student and instructor. For most engineering undergraduate students, this sense of intimidation, reluctance to vocally communicate, or engage during lecture sessions, despite having inquiries, may attribute to the instructors' inability to implement pedagogical methods that simplify technical depth and abstract themes constituted in the curriculum. Such inability may consequently produce an uncomfortable climate setting which obstructs a healthy scholarship development.

Oftentimes instructors indirectly establish barriers that hinder communication with students such as the absence of a well-structured curriculum, insufficient motivation to disseminate content, lack of clarification on abstract topics, or even unwillingness to establish communication channels outside the classroom. Other instances, communication vanishes when lecture sessions at the undergraduate level periodically drift to research themes rather than consolidating fundamental engineering principles. When such wandering transpires, students tend to disengage and abstain from participating during lectures due to the abstract technical content presented outside their level of understanding.

II. PROPOSED WORK

Therefore, favorably articulating during lecture sessions and intentionally creating a healthy learning environment in which engineering students feel comfortable engaging and inquiring about abstract themes requires reframing the learning context and implementing additional pedagogical resources in the classroom. In this study, the authors posit that such healthy learning environment can be generated by simultaneously incorporating various types of communication channels that eliminate intimidation barriers and promote student engagement. Particularly, four communication strategies have been identified as pedagogical resources: 1) verbally encourage student participation during lecture sessions; 2) communicate with students before and after class; 3) learn student names; and 4) pose non-intuitive questions that spark curiosity (Figure 1).

This emerging model, termed ECNQ (e.g., acronym for Engage, Communicate, Names, Questions), is an active and dynamic approach to engaging students in the engineering classroom and works towards disrupting traditional normalized, ineffective teaching practices that limit and/or stifle student participation by helping to engender conditions for deep learning, active participation, and engagement. Three main sources provided the foundation for development and refinement of the model proposed by the authors: a) teaching practices employed by the author during lecture sessions; b) post course analysis of teaching experiences; c) literature on instructional best practices. The combination of experiential knowledge, post course reflection and scholarly literature provided a framework through which the purposed model was conceptualized, developed, and implemented.

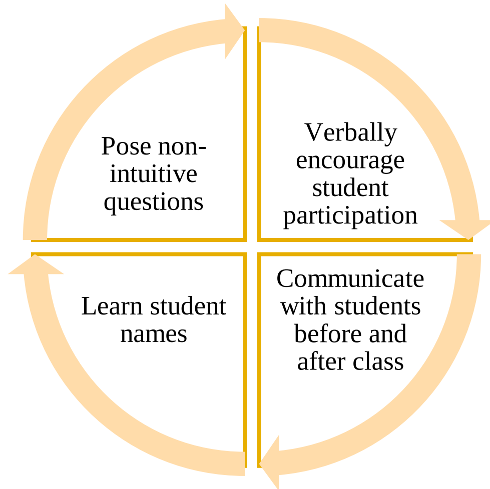

Figure 1. Proposed ECNQ Model

Strategy 1. Verbally Encourage Student Participation

In the first strategy, the authors address the notion of intimidation, reluctance to vocally communicate, or participate during lecture sessions by finding it imperative and necessary for faculty members to initiate the process of verbally encouraging and soliciting student participation during lecture sessions, and emphasize that inquiries in engineering related disciplines are vital to learning. By enacting on this proposition, engineering instructors can foster an intellectually rich, healthy environment that mutually stimulates and privileges diverse modes of inquiry. In this process, nonetheless, waiting on student inquiries is not recommended, instructors must initiate the process of encouraging student participation as deemed appropriate, particularly, when abstract themes are covered or when students seem perplexed about a specific topic. Therefore, instructors must consistently and closely monitor student reactions when disseminating content.

For this communication strategy to be effective and resonate with students, it must be incorporated recurrently throughout the semester. It may be implemented periodically during the introductory part of class, throughout lecture when abstract themes are being covered, or once the instructor recognizes student confusion. As such, the authors recommend that verbally encouraging student participation should be integrated during every lecture session for optimal results. Students must be constantly aware that the instructor is interested in their participation and open to discussion. Oftentimes student engagement and interest are absent given that the instructor maintains a constant dialogue throughout the lecture, goes off tangent in various topics, or indirectly establishes barriers that hinder communication.

Strategy 2. Communicate with Students Before and After Class

Verbally encouraging student participation is not the only communication channel needed to create a learning environment in engineering related disciplines according to the authors. Walberg and

Boy *et al.*, for instance, identified that educational productivity is dependent on the psychosocial environment of the classroom [7], [8], [9]. However, a healthy psychosocial environment is constantly affected in higher education due to the level of intimidation instructors exert on students given their notable academic status. Such discomfort, in numerous instances, precludes student engagement during lectures, regardless on the recurring emphasis of fostering participation. The authors in this study have identified that establishing a consistent communication, or rapport, with the students can alleviate discomfort, eradicate intimidation barriers, and create a classroom climate that impacts learning, engagement, and success.

The communication strategy is proposed to eliminate the notion of unapproachability and seclusion of student success by the instructor. Studies reveal that teacher-student relationships in classroom settings are a significant characteristic in healthy learning environments [9]. As such, the instructor is highly recommended to arrive a few minutes prior to class and randomly initiate conversation with the students. It may be regarding lecture related material, or a simple greet that demonstrates interest in their well-being.

Strategy 3. Learn Student Names

In developing and pursuing practical, effective channels of communication in an engineering classroom setting, the authors find it insufficient to exclusively incorporate *Strategy 1* and *Strategy 2* as a means of promoting student engagement. A complementary pedagogical resource integrated in this research study involves referencing students by their name during or outside lecture sessions. This third communication strategy was inspired by the psychological effects that promote educational productivity [7] and established to strengthen the faculty-student rapport and encourage a healthy classroom environment.

As simple as the communication channel may appear, it bears a significant impact on the students' psychological aspect, particularly, as value and respect are procured as a name is frequently utilized and remembered. Dale Carnegie postulates in his book that a name is the sweetest and most important sound in any language [11]. As such, engineering instructors are strongly recommended to identify students by their names, and when possible, reference them during lectures or outside the classroom. This communication approach is beneficial to both parties as it nurtures relationships and establishes a sense of community, or bond, within the class.

Strategy 4. Pose Non-intuitive Questions that Spark Curiosity

A preeminent duty of an engineering educator is to capture students' attention during lecture sessions and spark interest in specific themes or disciplines. This responsibility, however, cannot effectuate by simply mastering the technical content delineated during lecture sessions. It requires implementing effective pedagogical techniques when disseminating technical content that will extract the inquisitiveness about certain themes. As such, the authors find it necessary for engineering instructors to pose non-intuitive questions during lecture sessions as a strategic mechanism to engage students.

The effectivity of this pedagogical approach depends on enforcing the previous three communication strategies. Once the instructor has established a consistent form of communication by encouraging participation and referencing student names, the instructor is recommended to pose non-intuitive questions during lecture sessions to ignite technical curiosity and engagement. The proposed communication strategy is a valuable tool since generally the instructor occupies substantial lecture time and allows minimal gaps for inquiries or participation. It gives students an opportunity to develop engineering aptitudes, be synthesized to details beyond textbook context, and engage with the instructors' technical expertise.

III. METHODS AND ANALYSIS

To help contextualize the research study, the authors draw upon a social constructivist theory to guide the research and meaning making process. Social constructivist theory posits that knowledge is actively constructed by individuals through engagement in different social settings and interactions [12]. This perspective on knowledge views the learners as active participants in the learning process and positions educators as facilitators to create the conditions that support and nurture inquiry, relationships, and collaboration. This theoretical position provides a framework through which student experiences are examined and learning environments are structured and enacted by the educator.

For this study, the proposed ECQN communication model was piloted with 52 undergraduate students (Table 1) enrolled in an introductory engineering course at a small private research university in Texas to inquire into its effectivity. Student classification ranged from freshmen to seniors pursuing Mechanical Engineering, Bioengineering, Civil Engineering, and Materials Science.

Table 1. Student Demographics of Piloted Course

Variable	Total	Percentage
Gender		
Females	18	33.96 %
Males	35	66.04 %
Classification		
Freshman	1	1.89 %
Sophomore	36	67.92 %
Junior	15	28.30 %
Senior	1	1.89 %

Primary methods of data collection employed in the study involved a self-developed, small survey instrument administered electronically via Qualtrics, and focus group student interviews. For the focus group interview segment, participants were invited to partake in the study via email. A total of six, half-hour duration group interviews were utilized to facilitate collective reflection, dialogue, and provide students with an opportunity to openly discuss learning experiences with fellow peers. The number of participants ranged between 6-8 and all focus groups sessions were audio recorded for transcription and analysis purposes. The dynamic nature of the focus group method stimulated conversation among the students and sparked conversations centered on their unique experiences related to the course. Focus group interviews employed a semi-structured approach in which the researchers generated a series of open-ended questions to guide group conversation. This approach created an organic, conversation-oriented environment that encouraged participant autonomy and respected individual and collective experiences and stories.

As such, the administered survey consisted of two segments. The first involved extracting information related to the effectivity of the four proposed communication strategies, particularly, strategies 1, 2, and 4. A total of eight questions were outlined with the following response options: *Strongly Agree, Agree, Neither Agree or Disagree, Disagree,* and *Strongly Disagree*. Questions on the survey included:

1. The professor encouraged participation during lectures.
2. The professor posed non-intuitive questions to spark curiosity
3. I found the professor to be an approachable person.
4. The professor created an environment where I was comfortable asking questions
5. I felt the professor created a friendly environment in class
6. I was motivated to engage during lectures
7. The professor encouraged email communication
8. The professor was responsive to my email communications

The second segment of the survey included open-ended questions that aimed towards exploring the perceptions of students regarding the classroom learning environment of the piloted course. Such questions were utilized to understand which ECNQ strategies exerted a greater influence on students.

Lastly, a focus group segment was conducted to determine additional perspectives about the value of the instructor to nurture a safe, responsive learning environment. This segment aimed towards extracting feedback regarding *Strategy 2* and *Strategy 3* of the recommended ECNQ model. These sessions followed a semi-structured format in which a list of guiding questions was developed to inform and facilitate conversation among the students but not restrict or bound the synergistic potential of group dialogue.

IV. RESULTS

The first segment of the administered survey inquired into the effectivity of the proposed communication strategies, particularly, strategies 1, 2, and 4. To extract the necessary feedback, a total of eight questions were delineated. Preliminary results, displayed in Table 2, indicate students' positive attitudes and perceptions concerning learning environment context and conditions. In terms of assessing the significance of *Strategy 1*, 98% of the class population agreed that the engineering instructor encouraged participation during lecture sessions. These results reveal the initiative of the faculty member to verbally encourage student participation during lecture sessions and emphasize that inquiries in engineering related disciplines are vital to learning.

Table 2 additionally exhibits that 26.92% and 48.08% of the students strongly agreed and agreed, respectively, the instructor posed non-intuitive questions during class to spark curiosity about related topics (*Strategy 4*), while 19.23% neither agreed nor disagreed on such matter. It is evident that the faculty member was mostly effective on implementing a pedagogical technique which captured the attention of the students and stimulated participation. Results affirm that posing non-intuitive questions during lecture sessions, as a strategic mechanism, to engage students is an imperative procedure that gives students an opportunity to develop engineering aptitudes and be synthesized to technical details beyond textbook context.

Table 2. Student Responses

Question	N	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
1. The professor encouraged participation during lectures.	52	57.69 % (30)	40.38 % (21)	1.92 % (1)	0.00 %	0.00%
2. The professor posed non-intuitive questions to spark curiosity.	52	26.92 % (14)	48.08 % (25)	19.23 % (10)	5.77 % (3)	0.00%
3. I found the professor to be an approachable person.	52	73.08 % (38)	23.08 % (12)	1.92 % (1)	1.92 % (1)	0.00%
4. The professor created an environment where I was comfortable asking questions.	52	59.62 % (31)	32.69 % (17)	5.77 % (3)	1.92 % (1)	0.00%
5. I felt the professor created a friendly environment in class.	52	61.54 % (32)	32.69 % (17)	5.77 % (3)	0.00 % (0)	0.00%
6. I was motivated to engage during lectures.	52	36.54 % (19)	32.69 % (17)	25.00 % (13)	5.77 % (3)	0.00%
7. The professor encouraged email communication.	52	34.62 % (18)	42.31 % (2)	19.23 % (10)	3.85 % (2)	0.00%
8. The professor was responsive to my email communications.	52	36.54 % (19)	40.38 % (21)	19.23 % (10)	3.85 % (2)	0.00%

The second communication strategy (e.g., communicate with students before and after class) was intended to eliminate the notion of unapproachability and seclusion of student success by the instructor. As such, students were asked to provide feedback on the approachability of the instructor in question 3 of Table 2. According to results, over 95% of the students found the engineering professor to be an approachable person. This critical finding indicates that the instructor focused on the psychosocial environment of the classroom and established a consistent rapport with the students that impacted learning, engagement, and success. Similarly, at least 75% of the students specified that the instructor encouraged and was responsive to email communication, which is an alternative channel that strengthens a student-faculty connection.

Similarly, over 90% of the students strongly agreed (59.62%) or agreed (32.69%) that the professor established a learning environment in which they felt comfortable inquiring during lecture sessions. Such outcome highlights the efficacy of *Strategy 1* and the need for faculty engagement during lecture sessions such that a healthy environment and student participation emerges. However, only approximately 70% of the students were motivated to engage during the lectures, which indicates that a limited number may still be hesitant, or apprehensive about inquiring.

As a collective assessment, this preliminary data reveals that engineering students are overall receptive to participate during lecture sessions when learning environments are structured to promote student involvement. Such data suggests the need for faculty members in engineering related disciplines to consider educational factors that impact student engagement such as learning environments. Faculty members should be strongly committed in creating a socially safe, yet intellectually rich learning environment which minimizes traditional power dynamics and promotes student engagement and participation.

As such, preliminary results of the piloted study indicate that utilizing the four communication strategies of the ECNQ model minimizes traditional classroom power relations, strengthens student-instructor communication, increases student collaboration, and fosters an active learning environment that enhances student engagement and learning.

Student Comments

The second segment of the survey included open-ended questions that aimed toward exploring thoughts and perceptions regarding classroom learning environment. Such questions were utilized to understand which ECNQ strategies exerted a greater influence on students. Ten of the students surveyed noted that classroom-learning environment related factors were significant in supporting their learning experiences. Emerging themes included pedagogical style and effectiveness, mastery of content knowledge, and responsiveness to engage with students. Based on student remarks, the ability of the instructor to engage and capture students' attention was a critical component which motivated greater performance efforts and enhanced interest in the material. Three students offered the following thoughts:

> "*Teaching style was engaging, it could be summed up in three words: bold, passionate, and helpful."*
>
> "*Lectures were extremely engaging and allowed me to process the most difficult concepts in the class. The instructor was very engaging and connected with us."*
>
> *"I think the ability to engage the class really helped me be more interested in the material."*

Furthermore, a student noted that the instructor is *"very approachable and easy to ask questions to."* These comments reveal the instructor's disposition and responsiveness to engage with students and the usefulness of *Strategy 1* and *Strategy 2*.

Another student shared that "*instructor made an amazing environment to learn and ask questions,"* while a colleague echoed the remark by stating "*instructor fostered a responsive environment and was very approachable as a person."* Lastly, a student shared the following about the instructor, "*responsive with his emails and encouraged people to come to his office hours."* This remark resonates with previous student responses which indicate that the instructor encouraged and was responsive to email communication.

From the shared comments, it is evident that *Strategy 1*, *Strategy 2*, and *Strategy 4* of the ECNQ model exert a greater influence on the students. Thus, it is necessary for faculty members to initiate the process of verbally encouraging student participation during lecture sessions and emphasize that inquiries in engineering related disciplines are vital to learning. In addition, it is the consistent rapport with the students which can eradicate intimidation barriers and create a classroom climate that impacts learning, engagement, and success.

Focus Group Interview Comments

The focus group segment aimed towards extracting feedback regarding *Strategy 2* and *Strategy 3* of the recommended ECNQ model. During the interview process, several students shared their perspectives regarding the value of the instructor to nurture a safe, responsive learning environment. Focus group sessions followed a semi-structured format in which a list of guiding questions was developed to inform and facilitate conversation among the students but not restrict or bound the synergistic potential of group dialogue. This approach allowed for more student-directed conversations that evolved organically and helped to increase levels of student autonomy and engagement. One student shared the following reflection:

> *"I feel like also in terms of building a safe learning environment or where people feel comfortable sharing the instructor does a good job in just the small things like the personal things that make you feel like he has confidence in you, just like knowing your name and things like that. Just being able to have the ability to personally interact with him it like instills like the fact that he believes that you can like learn what he's teaching and that like in of itself helps you to believe that you can learn what he's teaching."*

Another student offered the following thoughts:

> *"I think from all my professors he probably does like the best at making a space just because he learns our names or he's just very friendly like saying good morning or stuff like that and just willing to answer questions at least for the most part when he has time to answer questions in class. If he sees one of us maybe stuck, he notices like… just paying attention to the little things. I think it definitely creates a safe environment for us to learn and ask questions and participate. He makes you feel pretty comfortable in class. He cracks a bunch of jokes every now and then, whether they're good or just awful and it just makes you feel like it's the chill class, you're kind of more into it."*

These thoughts demonstrate the effectivity of *Strategy 2* and the willingness of the faculty member to invest in building a rapport with the students by engaging in conversations regarding lecture related material, or a simple greet that demonstrates interest in their well-being. It is apparent the need to integrate the alternative pedagogical resource to reference students by their name (*Strategy 3*) during or outside lecture sessions. In doing so, educational productivity is promoted, faculty-student communication is strengthened, and a sense of community, or bond, within the class is built.

In addition, these shared responses shed light on the importance of the quality of the instructional methods and pedagogical practices enacted in the engineering classroom by faculty. As more institutions commit valuable resources and energies to achieve or maintain tier 1 research status, the quality of teaching may be adversely affected and ultimately impact the level of student engagement and achievement outcomes. The nature of shaping a learning environment that is conducive to positive student learning and engagement is rooted in the relational and social aspects of the student/teacher dynamic. As evidenced by the student comments above, these insights compel practicing faculty members to critically reassess existing personal and departmental pedagogical models and methods enacted in the classroom and recommit to ensuring all students have access to high quality teaching.

V. CONCLUSION

Favorably articulating during lecture sessions and intentionally creating a healthy learning environment in which engineering students feel comfortable engaging and inquiring about abstract themes requires reframing the learning context and implementing additional pedagogical resources in the classroom. In this study, the authors posit that such healthy learning environment can be generated by incorporating various types of communication channels that eliminate intimidation barriers and promote student engagement. Four communication strategies were identified as pedagogical resources: 1) verbally encourage student participation during lecture sessions; 2) communicate with students before and after class; 3) learn student names; and 4) pose non-intuitive questions that spark curiosity. Preliminary results of the empirical study indicate that utilizing the four communication strategies of the ECNQ model minimizes traditional classroom power relations, strengthens student-instructor communication, increases student collaboration, and fosters an active learning environment that enhances student engagement and learning. These findings support existing literature content which elucidates the importance of cultivating a learning environment that encourages class participation and engagement. As such, faculty members assume the responsibility of nurturing students' intellectual capabilities by incorporating communication channels that eliminate nonexistent acquaintances in classroom settings and foster a sense of belonging and engagement.

Ongoing and Future Work

Despite the promising results of the piloted study, further actions are necessary to rectify the structure of existent engineering [graduate] programs which fail to enforce formal pedagogical preparation through the respective curricula. The absence and lack of receptivity to formal pedagogical training causes numerous scholars who attain faculty positions to struggle with identifying and incorporating effective instructional techniques that nurture healthy learning environments.

However, before any rectification can occur, relevant data needs to be extracted that validates the need for pedagogical training. As such, the authors are in the process (Phase 2) of developing various strategies to collect student data from those enrolled in undergraduate engineering courses (at the respective institution) and evaluate classroom environments fostered by instructors. Primary methods of data collection will include a self-developed, small survey instrument administered electronically, and focus group student interviews. However, students will not be the only source of data collection. It is the intention of the authors to interview the corresponding instructors to attain a well-balanced perspective on potential instructional issues that hinder academic development.

While Phase 2 of this long-term project is in process, it is the intention of the authors to present the benefits of implementing the ECNQ model to the Mechanical Engineering faculty such that its implementation is considered in their respective courses. The authors are planning to develop a seminar series that illuminate practical examples and explore pragmatic processes that strengthen student learning and engagement by incorporating effective communication strategies during lecture sessions. Resultantly, Phase 3 of the project compromises engaging with faculty members from various departments in the School of Engineering with the intention of presenting the need strengthening pedagogical practices and promoting healthy learning environments through the ECNQ model.

Once student and faculty assessments are completed, Phase 4 of the project involves presenting the corresponding findings to the School of Engineering with the intention of integrating a formal pedagogical training into engineering graduate curricula.

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