A Formula for Success

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Scientists often struggle with how to improve diversity in their field, in part because the problem seems overwhelmingly complex and multi-faceted. Here we attempt to lead women, minorities and others toward success using the tool that many physicists love best: the equation.

In the ongoing quest to increase diversity in science and engineering, one of the key challenges is identifying which factors can help women and minorities to succeed. To find answers, we decided to get, well, scientific about it. In many of our workshops designed to help underrepresented groups advance in science, we've often heard participants say, "I wish there was an equation for that." So we decided to make one.

Finding the variables

First, we looked to the National Science Foundation to identify the parameters they use to invest in programs geared toward advancing the careers of diverse populations. These included adequate funding, continuous mentoring and rigorous preparation.

Next, we examined the charters of organizations devoted to promoting scientific diversity—such as PROM-ISE AGEP, the National Society of Black Engineers and the Society for the Advancement of Chicano and Native American Scientists—to identify how these groups help their members to accomplish their professional goals.

And finally, we used African-American physicist Shirley Ann Jackson's

"Power" equation as a basis for predicting the characteristic behaviors required for success in science and engineering (see Eqn. 1 below).

Building on Power

We expanded the Power equation with the additional variables we found through our research to create a new

Power and "momentum of success" equations

$$Power = \underbrace{\frac{\{P_1^{10}\,(P_2 + P_3)\}}{P}} + \underbrace{\frac{\{C_1^{10}\,(C_2 + C_3)\}}{C}} + \underbrace{\frac{\{E_1^{10}\,(A + W)\}}{E}} \qquad (1)$$

$P = \{Preparation^{10}(Passion + Persistence)\}$
$C = \{Connection^{10}(Compassion + Courage)\}$
$E = \{Excellence^{10}(Achievement + Wisdom)\}$.

$$\gamma(t) = \int_1^t \underbrace{(6 - T_1)/5}_{\text{fear factor}} \cdot \left(\underbrace{(T_2 + \hat{P} + \hat{E})^{f/2}}_{\text{what you bring}} + \underbrace{(M + T_3)}_{\text{what you receive}} + \underbrace{(R \cdot O \cdot \hat{C})}_{\text{your environment}} \right) dt \qquad (2)$$

$\gamma(t)$ = "the momentum of success" at a given time.

t = the time that it takes for you to reach your academic/career goals.

T_1 = timidity, hesitation or the inability to act due to fear (literally the fear factor).

T_2 = talent, or the ability to understand and apply advanced math and science concepts.

T_3 = teaching, the scope of instruction available to you.

f = focus, the level of concentration you apply to your work.

R = the resources, people, programs and funding that surround you and have the potential to help you.

O = for the opportunities you have to add to your knowledge, skills and abilities.

M = mentoring, $M = (2M_1 + M_2)$, or advice received from others who have more experience.

$\hat{P}$ = {Preparation (Passion + Persistence)}

$\hat{E}$ = {Excellence (Achievement + Wisdom)}

$\hat{C}$ = {Connection (Compassion + Courage)}

formula for Success. While there is no magic "solution" for this formula, we feel that it can be a good tool to guide people in graduate school and beyond.

The first part of the process involves determining one's momentum of success, or the value of applying power over time (see Eqn. 2 on facing page).

Got all that? The momentum equation emphasizes that the appropriate application of these components over time will increase the likelihood of success. The objective is to continuously maximize $\gamma(t)$, representing an accumulation of skills, access to a supportive environment and one's willingness to utilize resources.

Getting a quantitative result

First, you'll need to assign numerical values to each of the variables in the equation. Use the table to the right to gauge your perceptions of success characteristics. Apply the following scale to each of the statements in the table:

1. Strongly disagree
2. Disagree
3. Neither agree nor disagree
4. Agree
5. Strongly agree

When you're done, plug the numbers into the Success equation to get your $\gamma(\text{now})$, or success momentum, at the present instant. Then apply the following formula:

$$\text{Success} = \log_{10}[\gamma(\text{now})]. \qquad (3)$$

Here's how to interpret your score:

If your score is low: < 2.38
You have work to do in order to overcome barriers to success, such as distractions; difficulty with core concepts or skills; not being engaged with mentors; not participating in scientific organizations; and experiencing nervousness about presenting papers, connecting with professors or approaching others for help. Start with some of the easy fixes—such as attending more meetings, joining an

Quantifying academic or professional success		My score (1-5)
The fear factor		
T_1 = Timidity	I am intimidated by unfamiliar experiences, allowing fear to prevent me from acting.	
What you bring		
T_2 = Talent	I am able to understand and apply advanced math, engineering and science concepts.	
P_1 = Preparation	I apply hours of deliberate practice and regularly have preliminary work completed in advance of classes/meetings/conferences.	
P_2 = Passion	I am self-directed in the depth and breadth of my pursuit of solutions to problems in my research area.	
P_3 = Persistence	I continue to pursue my goals with vigor after receiving disappointing results (e.g., low grades, criticism, an unfavorable review and failed experiments).	
E = Excellence	I regularly present work that is of the highest quality. It is innovative and relevant.	
A = Achievement	I successfully and thoroughly complete tasks on time or ahead of time.	
W = Wisdom	I exhibit integrity, common sense and good judgment with regard to professional relationships.	
f = Focus	I prioritize and concentrate on the task at hand without conceding to distractions.	
What you receive		
M_1 = Mentoring from internal mentors	I pursue and follow the advice of my faculty or direct supervisors.	
M_2 = Mentoring from external mentors	I pursue and follow advice from professional mentors who are faculty members at another university or top leaders in my research area.	
T_3 = Teaching and learning	I pursue information to improve my understanding of concepts in my field.	
Your environment		
R = Resources	I take advantage of resources that surround me (e.g., senior lab members, support programs, workshops and supervisors).	
O = Opportunities	I take advantage of opportunities that add to my resources, knowledge, skills and abilities (e.g., internships and conferences).	
C_1 = Connections	I have a strong network of colleagues, peers and acquaintances who know about my work and can attest to its quality.	
C_2 = Compassion	I respect my peers and colleagues and care about their well-being.	
C_3 = Courage	I am comfortable with asking questions and seeking answers from colleagues who have more experience, even when they seem intimidating.	

organization and finding a mentor, and work your way up from there.

If your score is in the mid-range: 2.39 to 3.60

You show promise and you've done some work to engage in the field, but you could be more proactive. People in this range might attend conferences but not present at them; talk with professors prior to a test, but not at other times; meet infrequently with supervisors; or experience occasional fears about their abilities. If this is where you fall, your work is cut out for you; work on taking your efforts to the next level and fine-tuning your confidence.

If your score is high: >3.61

You have a high level of engagement, performance and preparedness. You regularly interact with relevant organizations; you have contacts and support outside of your professional base; and you don't let fear prevent you from approaching colleagues to ask questions or pursue professional opportunities. In other words, you rock! Try mentoring a student or colleague who may be struggling.
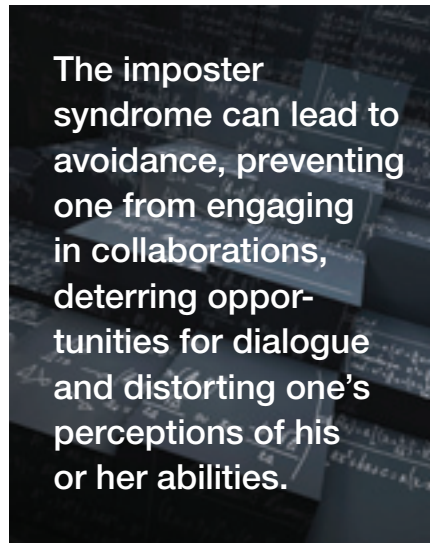
Case studies

To demonstrate how the Success equation works, we describe three people with three scores: Alice, Bob and Carol. The table above and to the right shows sample responses for these individuals.

Alice finds that her lack of focus (f = 2), little engagement with internal and external mentors (M_1 = 2, M_2 = 1), and lack of preparation and passion (P_1 = 2, P_2 = 2), among other variables, corresponds to a score of 1.39. There is a strong need for improvement.

Bob is smart and hard-working, but fearful. He finds that he doesn't take advantage of his resources (R = 2) or have a strong network (C_1 = 2). His score is 2.67, implying that more active engagement with colleagues and mentors could be helpful.

Carol is talented and confident. Her focus is strong (f = 4); she is engaged

Sample scores for the Success Equation			
Success variable	**Alice** Timid, not well-prepared	**Bob** Smart and hard-working, but fearful	**Carol** Talented, impeccably focused and confident
T_1	5	5	1
T_2	2	5	4
P_1	2	2	4
P_2	2	2	4
P_3	3	3	4
E	2	4	4
A	2	4	4
W	2	4	4
f	2	4	4
M_1	2	2	5
M_2	1	1	3
T_3	2	2	4
R	2	2	4
O	4	4	4
C_1	2	2	4
C_2	5	5	4
C_3	1	1	4
Success score from Eqns. 2 & 3	1.39	2.67	3.71

The imposter syndrome can lead to avoidance, preventing one from engaging in collaborations, deterring opportunities for dialogue and distorting one's perceptions of his or her abilities.

with mentors (M_1 = 5, M_2 = 3), and she has other factors that give her a score of 3.71, indicating a propensity for success.

Bob and Alice may suffer from a specific form of fear known as the imposter syndrome, which disproportionately affects minorities and women. It can be defined as an inability to accept your own success and the feeling that your

successes are the result of chance rather than hard work; it is the sense that you are somehow "faking it."

The imposter syndrome can lead to avoidance, preventing one from engaging in collaborations, deterring opportunities for dialogue, and distorting one's perceptions of his or her abilities. When one's "fear factor" (T_1) factor is high and the courage score (C_3) is low, that should serve as a red flag that fear is a significant problem, and the imposter syndrome may be playing a role.

As diverse groups ponder how to succeed in graduate school and their careers, the success equation can inspire awareness of the variables that influence success. The formula is not intended to define people with numbers, but rather to give them a tangible, practical way to work towards success and continually assess their performance. Just do the math! ▲

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