COMMENTARY

Mathematical Models for Human Performance: Borrowing From the Physics Domain

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The field of human and organization performance lacks standardized and proven mathematical formulas that researchers can use to build studies and experiments and through which practitioners can increase the likelihood of developing and implementing effective solutions.

It has been argued that no single approach can impact performance and that no one mathematical formula can capture the elements through which a standardized formula could be employed. Instead, our best hope is to increase our ability to improve the probability that the performance we desire will actually occur.

Gilbert (1996) suggests that worthy performance results from the production of a valuable accomplishment at an acceptable cost. Wittkuhn (2004) reconfirms that performance is a function of many variables and offers a regression-like concept for consideration. Although these are accurate generalities, they do not advance the capability of the human performance profession to diagnose deficiencies, select appropriate solutions, or measure the impact of applied interventions.

In recent months, we have been asked numerous questions about defining and measuring performance. These questions include the following:
- Is performance productivity or is it just capability?
- Is performance potential or is it outcomes?

As we seek answers to these seemingly basic questions, we encounter extraordinary underlying complexity. After all, we are dealing with the behavioral and cognitive capabilities of people. But we also find that, as a profession, we have no underlying mathematical models that we can depend on to address this complexity. Therefore, it may be helpful to borrow from other domains.

This article summarizes our initial thoughts on how the study of physics may better contribute to our understanding of human performance. We begin by focusing on two basic equations for energy: potential and kinetic.

Potential Energy (PE) = Weight (W) x the change in Height (H)
Kinetic Energy (KE) = $\frac{1}{2}$M (Mass) x V^2 (Velocity)

Considering Potential Performance

In an attempt to define human performance in terms of physics, it may be that Potential Performance (PP) is the product of human capability (or Weight) and the change in task Significance (S), or PP = WS.

In an equation such as this, W for an expert would be very high (it is interesting to note that true experts in a field are often referred to as "heavyweights"). S is analogous to the magnitude or value of the project or assignment. So, a real heavyweight performer assigned to a trivial project faces a very low PP, and a relative novice assigned to something very important faces a high PP. Therefore, to increase PP and maximize benefit to the organization, managers would need to increase S by giving heavyweights more significant, complex tasks. "Potential" is the critical word because we are talking about Day 0 of a project; no performance has yet been realized.

This is an area that needs further investigation because, in physics, the heavyweight and the lightweight both dependably reach the bottom of a slope if pushed. How do we handle the calculation when it is possible that the lightweight may not accomplish the goal?

Perhaps there is a parallel if we imagine a rutted slope. On such a slope, a heavy object could roll right over the ruts; and a light, or smaller, weight could get stuck. In these cases, the PP for the smaller weight might only be based on the initial height above the rut in which it gets stuck, not on the overall height of the slope. This might require a calculation that includes the S for all potential activities in a given job or task, adding a challenging level of analytical and mathematical complexity.

Considering Actual Performance

Returning attention to our initial equation for PP, it may then follow that Actual Performance (AP), which we might define as a human in motion, has a kinetic cousin, something similar to $\mathbb{S}\ KE = \frac{1}{2}M(V2^2 - V1^2)$, where M is Mass and V is Velocity. AP is performance realized and comes from a change in PP. This permits us to suggest that $|\mathbb{S}\ PP| = |\mathbb{S}\ AP|$. Therefore, a decrease in PP would result in an equal and corresponding increase in AP, without taking into account resistance and friction, which are likely to come in the form of various organizational and environmental barriers (e.g., job design, expectations, feedback, organizational goals, incentives).

Many challenges arise when trying to develop a framework for one domain by relying on analogies from another. One challenge that we encounter here is the concept of mass. In physics, it is constant. In the human performance domain, we require an appropriate substitute.

If we presume that human performance mass is the bundle of capability, mood, motives, skills, and knowledge developed through years of training and experience, we have a very unstable factor. On the other hand, this factor can be considered a constant at a given point in time or on a given task of short duration. This, too, requires more investigation.

If weight, or mass, is related to a person's capability, velocity would be similar to the person's work rate. The friction factors that slow a person's work rate would remain. Again, a very capable but slow person does not generate much AP and can be outperformed on this parameter by a less capable person who works a lot faster.

Work and Power

Work is defined in physics as weight multiplied by the distance moved. This is the real measure of performance, how much is actually accomplished. Human performance "power," the rate at which work is performed, also bears consideration. A powerful performer will complete a unit of work in a shorter time than a less powerful performer or will accomplish more work in a given period of time.

Approaching performance from a power and work perspective may have more significance than a change-in-energy approach, as the latter begs the question, "Over what time period does this change occur?" Power or work (during a specific time period) circumvents this.

It may be of value to take the time consideration a step further. Earlier, we suggested that Performance is a product of task Value (V) and Capability (C), or P = VC. But what is more important is how much P can be produced in a unit of Time.

$$P = \text{rate of performance}$$
$$P = VC/T$$

To achieve high performance, we have three options:

- Increase V (task value increases)
- Increase C (person's capability increases)
- Decrease T (person does it faster)

Taking into consideration the total derivative with respect to time, our intermediate hypotheses are as follows:

- If organizational leaders desire rapid changes in their rate of performance value, they should avoid long cycle time tasks (unless they have very great value).
- If they have long cycle times for task completion and no change in C, they will be doubly challenged to rapidly change their performance value generation.

Torque

The concept of human "torque" is also very interesting, because the parallel to the moment arm could lead human performance researchers toward a further investigation into the use of tools. There are three variables affecting the ability to turn something:

- The force (which might be a person's physical ability)
- The leverage arm (possibly the person's understanding of the system)
- The actual torque needed for motion (which could include the organization factors)

Two equally capable people, one with good tools and one without, will certainly get different results. Again, a less-capable person with great tools can often accomplish more than a very capable person with poor tools. There is tremendous potential in using the idea of starting torque to further develop the idea that a person needs a minimum level of capability to use various tools effectively.

An unqualified person will not get any production out of even the best tools. Similarly, a weak person who cannot overcome the starting torque will not be able to loosen a bolt, even with a very good wrench.

Matching the Math to the Language

Systems theory provides us with a core set of terms, as do the behavioral and cognitive sciences. However, we find that many terms are modified, revised, and redefined by practitioners seeking various marketing advantages. This makes translation difficult.

Perhaps our approach should be to select core language terms, describe the improvement process mathematically as best as we can in those terms, and then look for well-understood analogies that fit the relations to the improvement process (be they mechanical, electrical, or biological). We may find that we need to create additional terms and concepts that are both meaningful and easily understood and that can lead to more complete relationships.

For example, when one thinks of the performance of a task, at least three things come to mind: exemplary performance, capable performance, and realized performance.

Beyond tasks, there are also job-level performance and organizational or team levels. Our models must be able to conceptualize at these levels as well. These are not subtle differences, as we may easily improve overall performance at the expense of some individual task performances (e.g., do better on high-value tasks but more poorly on low-value tasks, realizing an overall improvement).

Conclusion

In all of this there is the risk of pushing an analogy too far. The bottom-line focus remains the impact on the business. Rodger Stotz, Vice President and Managing Consultant at Maritz Inc., reiterates this focus. "What's important is identifying and linking the knowledge/human capital intangible—assets to business outcomes and financial results," says Stotz. "We are seeing organizations using these measures to model business outcomes and improve their ability to deliver increased shareholder value."

Although we believe that there is promise in physics-oriented mathematical inquiry, we recommend aligning the concepts with a common language, mutually understood concepts, and business results. In our collective inquiry, we may find that the field of human performance suffers in this regard as multiple consultants develop their own terminologies to create an imagined competitive advantage.

At the end of the day, organizational leaders want a number, a metric. To meet their needs, we recommend that our profession continue to seek answers to the mathematical questions outlined here. In doing so, we may be able to offer researchers, practitioners, and business leaders dependable models for advancing the organizations they support.

References

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