



Convergence Thinking: Reflections on Discovery, Education, and Innovation

Part 1/3 – Convergence: From Integration to Impact

The Central Idea: *"Convergence is often described as the integration of disciplines. I have come to believe that this is both correct and insufficient."*

There are words that quietly reshape entire fields. They begin as useful descriptors, become fashionable labels, and eventually find their way into grant solicitations, university strategic plans, keynote addresses, and journal editorials. Once there, they acquire a curious authority. We repeat them confidently, assuming we all mean the same thing.

Convergence is one such word.

During the past decade, convergence has become a defining aspiration for research universities, funding agencies, industry, and governments. Sharp-Langer (1) and the subsequent 2014 book **"Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond"** an output of the Committee on Key Challenge Areas for Convergence and Health within the National Research Council of the US National Academies (2), gave license to embrace this word in our scholarly lexicon. Today, we celebrate convergent research centers, convergent education, convergent innovation, and convergent technologies. Increasingly, proposals promise convergence simply by assembling investigators from multiple disciplines. Universities proudly announce institutes whose defining characteristic is that engineers, physicians, computer scientists, biologists, and social scientists now work together.

These are encouraging developments.

They are also, I believe, incomplete.

Convergence is often described as the integration of disciplines. I have come to believe that this is both correct and insufficient. Correct, because convergence almost always requires integration. Insufficient, because integration is not the reason convergence exists.

Disciplines are the raw materials of convergence. The true object of convergence is impact.

We do not pursue convergence because chemistry can be combined with biology, or engineering with medicine. We pursue convergence because humanity faces challenges whose impact demands the purposeful integration of knowledge, methods, people, technologies, and institutions.

Integration is the mechanism. Impact is the purpose.

That distinction may seem subtle, but it changes everything.

If convergence is merely the integration of disciplines, then success can be measured by counting departments represented on a proposal, listing co-investigators from different colleges, or creating new interdisciplinary centers. By that definition, convergence becomes largely an organizational exercise.

But if impact is the purpose, then the organizing principle changes entirely.

The question is no longer,

"Which disciplines should collaborate?"

It becomes,

"What knowledge must be intentionally brought together to create meaningful impact on this challenge?"

Notice what has happened.

The challenge—not the discipline—has become the starting point.

That is the intellectual shift that distinguishes convergence from earlier notions of multidisciplinary, interdisciplinary, or even transdisciplinary research.

This is not simply a semantic distinction. It is a philosophical one.

For more than four centuries, science has advanced through reductionism. We have sought to understand complex phenomena by studying their constituent parts. This approach has been extraordinarily successful. Every modern discipline owes its existence to this disciplined reduction of complexity into understandable components.

Reductionism remains indispensable. Indeed, convergence depends upon it.

One cannot intentionally integrate mechanics, chemistry, biology, medicine, ethics, economics, and artificial intelligence without first understanding each on its own terms. Convergence does not reject reductionism; it extends it. Reductionism explains the constituent parts. Convergence intentionally reunites those parts around a shared purpose.

It is tempting to think that convergence is therefore simply "more interdisciplinary or a higher level of interdisciplinarity." I do not believe that it is.

Interdisciplinarity seeks richer understanding through the integration of disciplinary knowledge.

Convergence seeks purposeful impact through the integration of disciplinary capability.

Understanding remains essential.

But understanding alone is no longer sufficient.

The difference is perhaps best illustrated by asking two seemingly similar questions.

The first asks,

"How can engineering and medicine work together?"

The second asks,

"How can engineering, medicine, biology, data science, ethics, entrepreneurship, regulation, and public policy be intentionally integrated to reduce the burden of cardiovascular disease?"

The first begins with disciplines. The second begins with a challenge.

One seeks collaboration. The other seeks impact.

The distinction matters because society's greatest challenges rarely present themselves as disciplinary questions. Healthy aging is not a biology problem. Climate resilience is not an engineering problem. Precision medicine is not a medical problem. Health disparity is not a geography problem. These are human challenges. They demand solutions that no single discipline, profession, institution, or technology can provide in isolation.

This, I believe, is why convergence has become so important.

Not because the boundaries between disciplines are disappearing.

But because the boundaries within our challenges never existed.

References:

1. P. A. Sharp, R. Langer, Promoting Convergence in Biomedical Science. *Science* **333**, 527–527 (2011).
2. N. R. Council, *Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond*. (The National Academies Press, Washington, DC, 2014), pp. 152.